REMEDIAL INVESTIGATION REPORT
REVISION THREE

ORMET CORPORATION
HANNIBAL, OHIO

TEXT

DECEMBER 29, 1992

PREPARED BY:

GERAGHTY & MILLER, INC.
WASHINGTON, PA

GERAGHTY & MILLER, INC.
Environmental Services

ORMET

REMEDIAL INVESTIGATION REPORT

PREPARED FOR
ORMET CORPORATION
HANNIBAL, OHIO

REVISION THREE
DECEMBER 1992

Prepared by

GERAGHTY & MILLER, INC.
Environmental Services
Washington, PA 15301

Robert L. Fargo
Associate/Principal Scientist
G&M Project Manager

Cleason P. Smith
Associate/Project Director
AIPG (CPGS #6624)
G&M Project Director

John Reggi
Ormet Project Coordinator

Rhonda McBride
USEPA Region V RPM

Richard Stewart
Ohio EPA Project Coordinator

CONTENTS

CONTENTS (CONT.)

CONTENTS (CONT.)

CONTENTS (CONT.)

CONTENTS (CONT.)

TABLES

TABLES (CONT.)

TABLES (CONT.)

FIGURES

FIGURES (CONT.)

FIGURES (CONT.)

APPENDICES

APPENDICES (CONT.)

EXECUTIVE SUMMARY

Introduction

In May 1987, the United States Environmental Protection Agency (USEPA), the Ohio Environmental Protection Agency (OEPA), and Ormet Corporation (Ormet) entered into an Administrative Order by Consent (Consent Order) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986. Under the Consent Order, Ormet was required, among other things, to conduct a remedial investigation (RI) to determine the nature and extent of any release or threatened release of hazardous substances, pollutants, or contaminants from the Ormet facility located at Hannibal, Ohio.

As provided for in the Consent Order, the RI was conducted in two phases. Field activities of the Phase I RI began in February 1988 and were completed in August 1988. The results of the Phase I RI were submitted to USEPA and OEPA in the form of a data report in October 1988. Based on the results of the Phase I RI, a scope of work for the Phase II RI was developed with the concurrence of USEPA and OEPA. The Phase II field activities were conducted from February 1990 through July 1990. The areas and media investigated during the two phases of the RI included the following:

- Former Disposal Ponds

- Former Spent Potliner Storage Area

- Carbon Runoff and Deposition Area

- Former Construction Material Scrap Dump

- Plant Recreation-Area Fill

- Ground Water

- Surface Water

- Sediments

- Air

- CAC Ranney Well

Site Description

The Ormet facility is located in Monroe County, Ohio and is situated along the west bank of the Ohio River, approximately 35 miles south of Wheeling, West Virginia, about 3 river miles upriver from Hannibal, Ohio. The Ormet property occupies the northeastern portion of the area known as Buck Hill Bottom, a lens-shaped stretch of land approximately 2.5 miles long and up to 0.5 miles wide (see Figure 1). The Ormet property is bounded on the northwest by Ohio State Route 7 and on the east and southeast by the Ohio River. To the southwest, the site is bordered by the Consolidated Aluminum Corporation (CAC) facility.

Since beginning plant operations in 1958, Ormet's main process has been the reduction of alumina to produce aluminum metal by the Hall-Heroult process. In this process, alumina is fed to a molten electrolyte bath contained in a series of electrolytic cells, or pots, and is reduced to aluminum. The pots are lined with prebaked blocks manufactured from a mixture of anthracite coal and coal tar pitch. This material, referred to as potliner, eventually deteriorates to a point at which it must be replaced.

During the period 1958 to 1968, approximately 85,000 tons of spent potliner material were placed in an open storage area located in the northeast portion of the Ormet property (see Figure 2). From 1968 to 1981, Ormet operated an onsite cryolite-recovery plant, which utilized caustic digestion to recover cryolite from the spent potliner. When the cryolite-recovery plant was put into operation, all spent potliner generated during the period of its operation was processed at the recovery plant. Almost all (≥95%) of the potliner accumulated in the former spent potliner storage area was also sent to the cryolite-recovery plant for processing, and the remaining potliner material was trucked offsite for disposal at a permitted facility during November of 1980. Due to the nature of the potliner removal operation (i.e., use of heavy equipment), a very small amount of residue from the potliner material became mixed with the underlying soils. It is estimated that the area of soil which may have been in contact with spent potliner is on the order of 10 acres.

At various times from 1958 to 1981, Ormet utilized one or more of five retention ponds (Ponds 1 through 5) located in the northeastern portion of the facility (see Figure 2). Ponds 1 through 4, which range from one to two acres in size and from 3.9 to 13.7 feet deep, received sludge from the pot-room wet scrubbing system and possibly from the wet scrubber for the anode bake furnace. Pond 5, which is about 13 acres in size and from 8.3 to more than 28 feet deep, was put into service to receive tailings from the cryolite-recovery plant when it began operation in 1968. Ponds 1 through 4 may have also received some minor amount of tailings from the cryolite recovery plant. The alkaline cryolite recovery system tailings in Pond 5 consist primarily of residual carbonaceous material from the potliner after its has been treated by the caustic digestion process. Beginning in 1971, chlorine was added to the tailings to destroy free cyanide, and beginning in the early 1970s, the tailings were neutralized in-situ by the addition of spent pickel liquor and later by adding sulfuric acid prior to being pumped to Pond 5. The combined volume of the material contained in the five

former disposal ponds is estimated to be on the order of 420,000 cubic yards, with Pond 5 accounting for about 370,000 cubic yards.

From about 1966 until mid-1979, Ormet deposited waste construction materials and other miscellaneous plant debris in the southeastern corner of the Ormet property, adjacent to Pond 5 (see Figure 2). This area, designated as the construction material scrap dump (CMSD), covers approximately 4 to 5 acres and contains accumulations of debris and earthern fill up to approximately 25 feet thick. The total volume of material and soil in the CMSD is estimated to on the order of 240,000 cubic yards.

Situated in a wooded part of the plant site to the west/southwest of the toe of the CMSD and immediately northwest of the Ohio River is an area referred to as the carbon runoff and deposition area (CRDA) (see Figure 2). The deposits of carbon material in the CRDA cover about 3 acres and range from less than one foot to approximately five feet thick.

Located on the slope leading down to the Ormet baseball field is an area of construction rubble that was designated in the RI as the Plant Recreation-Area Fill. Soil borings that were drilled adjacent to the area of construction rubble did not encounter any rubble material, indicating that the debris is limited to the face of the slope.

The Ormet facility utilizes a Ranney well, located in the southwestern corner of the facility (see Figure 2), to supply water for the manufacturing process. This well pumps at an average rate of about 2000 gpm, most of which is used for non-contact cooling. Changes in the quality of water

produced from the Ranney well, first noticed in 1971, prompted a series of site hydrogeologic studies to assess water-quality conditions and ground-water flow patterns beneath the facility.

Previous Investigations

The first hydrogeologic study at the Ormet site, performed by Fred H. Klaer and Associates (1972), included the installation of 20 monitoring wells (TH-series). Resultant data indicated that fluid was mounded beneath then-active Pond 5 and that affected ground water was being pulled from beneath the disposal ponds and potliner storage area toward the Ormet Ranney well. As a result of this investigation, two interceptor wells (#1 and #2) were installed approximately two hundred feet north of the Ormet Ranney well (see Figure 2) to intercept the plume before it reached this pumping center. Water from either interceptor well #1 or #2 is discharged to the NPDES-permitted 004 outfall (see Figure 2) with the approval of OEPA.

Water-quality data collected during a supplemental study by Dames and Moore (1978) indicated improvement in the quality of ground water in the vicinity of Pond 5. Water-quality data collected by Dames & Moore also suggested that ground water beneath the former spent potliner storage area exhibited slightly higher levels of contaminants relative to the 1972 condition (see Geraghty & Miller, 1984a which is provided as an appendix to the Phase I RI Work Plan).

In March, 1982, a third interceptor well (#3) was installed adjacent to the northwest corner of Pond 5 (see Figure 2), in an effort to intercept contaminated ground-water before it migrated toward the Ranney well. In June 1989, the operation of interceptor well #3 was discontinued with

the concurrence of USEPA and OEPA, after it was demonstrated that pumping of this well had no substantive effect on ground-water flow.

In October 1983, Geraghty and Miller was retained by Ormet to conduct a more detailed hydrogeologic investigation (Geraghty & Miller, 1984a). This study included the installation of nineteen additional monitoring wells (designated MW-1 through MW-20). The main findings from this study included the following: no natural discharge of ground water from the alluvial aquifer to the Ohio River occurs along Ormet's river/plant boundary due to the drawdown in the water table created by the pumping of the Ormet Ranney well; the Ohio River is the main source of recharge to the alluvial aquifer; the plume is contained within Ormet's facility boundaries by pumping of the Ormet Ranney well and interceptor wells; ground-water contamination related to Pond 5 had become greatly reduced since the 1972 study (see Geraghty & Miller, 1984a, which is provided as an appendix to the Phase I RI Work Plan) and; the existing plume of contaminated ground-water emanates mainly from beneath the former spent potliner storage area.

Following the 1983 study, Geraghty & Miller continued to sample, analyze, and evaluate ground water from the MW-series monitoring wells. These subsequent sampling and analysis programs were performed during September 1984 and May 1985 (Geraghty & Miller, 1984b and 1985). The results of these monitoring events, which were submitted to OEPA, indicated that ground-water flow patterns remained consistent with those previously mapped, plume containment continued to be maintained, and that slight improvements in plume quality might be occurring.

In October 1985, Geraghty & Miller performed a supplemental ground-water sampling and analysis program that included selected monitoring wells, interceptor well #1, and the 004 outfall (see

Figure 2). This work included analyses for Priority Pollutant organic compounds, of which toluene

was the only organic compound that was detected, at levels at or near the detection limit (Martell,

1985).

In February, 1986, Ormet directed Geraghty & Miller to identify and conceptually develop

feasible remedial alternatives to address the ground-water condition. This work included surface

geophysical surveys to identify possible source areas and plumes of contaminated ground water; soil

boring and analysis programs in both the former potliner storage area and the retention ponds to assess

the physical nature and chemical make-up of potential source materials; installation of 30 additional

monitoring wells (designated MW-21 through MW-40) at a total of 20 locations (see Figure 2); and

ground-water monitoring to further define ground-water flow patterns, the chemical make-up of the

plume, and plume/source-area relationships. The findings from this supplemental work were used

to design the RI/FS Scope of Work (SOW) attached to the Consent Order.

Remedial Investigation Findings

Former Disposal Ponds

The disposal pond sludges are generally characterized by an alkaline pH (i.e., pH greater than

7.0) and the presence of cyanide (below detection to 294 mg/kg, total CLP), fluoride (60 to 1600

mg/kg), chloride (5 to 556 mg/kg), sulfate (47 to 14,815 mg/kg), PAHs (7.61 to 693 mg/kg), and a

variety of metals. A summary of the metals detected in the disposal pond solids, as compared to

concentrations reported in natural soils is provided in Table ES-1. Only low concentrations of VOCs

TABLE ES-1
COMPARISON OF METALS CONCENTRATIONS
DETECTED DURING THE ORMET CORPORATION RI
WITH NATURAL SOILS(1)

(results in mg/kg)

	FORMER SPENT POTLINER STORAGE AREA			FORMER DISPOSAL PONDS			CARBON RUNOFF AND DEPOSITON AREA (carbon only)			FORMER CONSTRUCTION MATERIAL SCRAP DUMP			NATURAL SOILS(1)
	Minimum	Maximum	Mean(2)	Minimum	Maximum	Mean(2)	Minimum	Maximum	Mean(2)	Minimum	Maximum	Mean(2)	
Aluminum	2,560	42,500	12,223	48,000	105,000	74,598	56,500	107,000	76,128	58,800	121,000	89,950	70,000
Antimony	<11	<15	(4)	7.6	88	22	17	56	28	<3.4	<4.0	(4)	---
Arsenic	3	25	9.9	15	123	48	26	87	57	32.2	56.9	48	9.9
Barium	33	136	61	39	423	125	137	309	194	106	125	112	700
Beryllium	.23	2.2	.96	2.3	14	10	3.3	7.8	4.9	2.5	3.8	3.0	1.5
Cadmium	<1.0	<1.4	(4)	1.8	2.7	2.25	2.0(3)	2.0(3)	2.0(3)	2.0	3.6	2.7	---
Calcium	806	24,300	5,271	64,400	352,000	182,163	109,000	194,000	151,571	8,610	16,100	11,477	4,400
Chromium	4.8	168	22	6.4	119	29	14	47	27	2.0	30.2	21	100
Cobalt	1.9	13	5.4	2.0	19	8.5	1.8	18	9.3	4.2	11.4	7.15	15
Copper	8	791	104	12	130	52	32	94	62	303	542	401	30
Iron	6,690	106,000	26,744	3,180	13,600	6,369	5,210	12,200	8,701	21,800	26,900	24,325	30,000
Lead	7.2	74	20	13	214	64	24	85	54	54.7	83.9	67	30
Magnesium	661	2,930	1,469	1,220	4,000	2,327	2,110	4,500	3,060	901	1,670	1,280	3,000
Manganese	198	3,220	910	70	227	133	131	592	272	330	1,060	2,244	1,000
Mercury	.089	.098	.094	.14	.45	.27	.20	.30	.25	<.09	<.12	(4)	0.13
Nickel	8.8	146	31	19	656	172	61	558	222	36.6	58.8	49	30
Potassium	796	2,810	1,817	748	2,510	1,293	2,750(3)	2,750(3)	2,750(3)	311	1,150	752	18,000
Selenium	.31	.61	.45	7.6	44	26	<7.1	<10	(4)	<.97	<1.05	(4)	1.1
Silver	11(3)	11(3)	11(3)	2.4(3)	2.4(3)	2.4(3)	<1.4	<2.0	(4)	<.64	<.76	(4)	---
Sodium	1,190	14,200	5,549	6,410	46,100	16,194	7,830	11,500	9,835	22,300	48,700	34,675	7,000
Thallium	<.46	<.63	(4)	.67(3)	.67(3)	.67(3)	<.58	<.82	(4)	<.72	<.78	(4)	---
Vanadium	6.1	62	18	15	741	190	36	270	139	29.4	42.4	35	70
Zinc	24	109	56	16	170	38	28	107	51	7.9	21.7	16	50

(1) Donohue & Associates, 1991.

(2) Sum of values above the detection limit/# of values above the detection limit.

(3) Analyte was detected in only one sample from the sampling area.

(4) Analyte was not detected. Minimum and maximum columns reflect minimum and maximum detection limit.

GERAGHTY & MILLER, INC

(i.e., typically less than 0.1 mg/kg total and consistently less than 0.6 mg/kg total) were detected in the pond solids samples.   PCBs were not detected in any of the disposal pond solids samples.

Based on water-quality data from monitoring wells surrounding and directly downgradient from the former disposal ponds, any pond-related contributions to the ground-water condition are much less significant than any from the former spent potliner storage area. With regard to ground water around Pond 5, historical data have shown that following its decommissioning, ground-water quality exhibited substantial improvements (see Geraghty & Miller, 1984a, which is provided as an appendix to the Phase I RI Work Plan). Since the ponds are inactive, no increases in the downward movement of contaminants are expected.

There is no evidence that surface-water runoff represents a direct pathway for migration of contaminants from the disposal ponds. The dike around each pond is intact and prevents stormwater from exiting the pond surfaces to surrounding areas and media by surface-water runoff.   As discussed further in Section 3.5.2, work conducted during the RI suggests that precipitation that infiltrates in the area of Pond 5 contributes to the discharge of the ballfield seeps and possibly the discharge from the steel conduit that extends from the berm of Pond 5.

Based on the results of the Phase I RI air monitoring program and the particle-size analyses performed on samples collected from the pond surfaces, the surface of Pond 5 represents a potential source for the release of wind-blown respirable dust. However, the Baseline Risk Assessment performed by a USEPA contractor concluded that wind-blown respirable dust from the pond surfaces does not pose an unacceptable risk.

Former Spent Potliner Storage (FSPSA)

Soils affected in the FSPSA are characterized by a pH ranging from around 8.0 to 10.7 and concentrations of total cyanide (up to 2043 mg/kg), fluoride (up to 1648 mg/kg), and sodium (up to 83,750 mg/kg), which are regarded to be indicator parameters for FSPSA-related affects. PAHs were also detected in soils beneath the FSPSA at variable concentrations (up to 7067 mg/kg total). A summary of the metals concentrations detected in soil samples from the FSPSA, as compared to metals concentrations in natural soils is provided in Table ES-1.

Leaching of the soils beneath the FSPSA has affected ground-water quality beneath and hydraulically downgradient from the FSPSA. These affects to ground-water quality are most evident by the elevated pH, ranging from around 8.0 up to 10.5, and above background concentrations of total cyanide (up to 18.2 mg/L total CLP), fluoride (up to 1000 mg/L), and sodium (up to 2640 mg/L).

Other parameters identified in the ground water that appear to be related to the soil condition within the FSPSA are aluminum (up to 178 mg/L), TOC (up to 280 mg/L), silica (up to 4300 mg/L), iron (up to 144 mg/L), arsenic (up to 0.394 mg/L), chromium (up to 0.401 mg/L), cobalt (up to 0.814 mg/L), copper (up to 1.02 mg/L), nickel (up to 0.767 mg/L), and vanadium (up to 0.369 mg/L). Of these, aluminum, TOC and silica are attributed to the high-pH condition of the affected soils and water beneath the FSPSA, due to the increase in solubility that these parameters undergo in response to elevated pH. Iron concentrations in ground water beneath the FSPSA are thought to reflect the presence of iron-cyanide complexes, an interpretation that is supported by the occurrence of high total cyanide in ground-water samples containing high iron concentrations. The relationship that ground-water concentrations of arsenic, chromium, copper, cobalt, nickel, and vanadium may have

to the FSPSA is less certain, but may reflect the coal-derived materials composing the spent potliner, and the fact that most or all of these metals can be naturally present in coal.

The current drainage patterns in the area of the FSPSA do not permit surface water to migrate from the FSPSA.

Carbon Runoff and Deposition Area (CRDA)

Validated CLP analyses of samples of the carbon material and underlying soil collected from the CRDA by Geraghty & Miller detected low concentrations of several VOCs (typically less than 0.035 mg/kg and consistently less than 0.35 mg/kg) and did not detect any PCBs. Analysis of a single composite sample of carbon material obtained by the USEPA Environmental Response Team during the ecological survey detected Arochlor 1248 at 56 mg/kg. Concentrations of total PAHs were higher in the carbon material (15.151 mg/kg to 149.6 mg/kg), than in the underlying soil (up to 9.033 mg/kg), with the concentrations reported in the soil interpreted to be within the background range for natural soils. Concentrations of CLP total cyanide were higher in the carbon material (13 to 254 mg/kg) than in the soil (1.0 to 25 mg/kg), with cyanide amenable to chlorination typically below detection in the soils. A summary of the metals concentrations reported in samples of the carbon material from the CRDA, as compared to metals concentrations in natural soils is provided in Table ES-1.

As evidenced by the low concentrations of parameters such as PAHs, metals, and cyanide in the soils, relative to the levels of these parameters in the overlying carbon, vertical migration of constituents from the carbon deposits has been very limited. This is due to the very low permeability

(10^{-7} to 10^{-8} cm/sec) of the soils that underlie the CRDA. Consequently, the CRDA has little or no potential to contribute to the plume in the alluvial aquifer. The topography of the CRDA is relatively flat, with much of the area covered by grasses and trees. Two localized portions of the CRDA are devoid of vegetation and are subject to erosion and are within the 100-year flood plain. Although the areas is relatively flat, it is subject to surface-water runoff and the carbonaceous material deposited in the CRDA is similar to the carbonaceous material in the 004 backwater area.

Construction Material Scrap Dump (CMSD)

Laboratory analyses of composite samples collected from the test pits in the CMSD detected a variety of organic and inorganic constituents, which is a result of the assorted nature of the materials present in the CMSD. Several VOCs were detected in the CMSD samples, but at low concentrations (from below detection to 0.043 mg/kg). The only semi-volatile organics detected in the CMSD test pit samples were PAHs, with total concentrations ranging from 297.06 mg/kg to 1981.5 mg/kg. The PCB Aroclor 1248 was detected in each of the CMSD solids samples, at concentrations from 3.632 to 22.6 mg/kg. Analyses of a grab sample of an oil/water emulsion that was encountered in Pit #2 detected Aroclor 1248 at 0.725 mg/L.

CLP total cyanide concentrations in the samples from the CMSD ranged from 7.90 to 21.7 mg/kg and cyanide amenable to chlorination was below detection. Fluoride levels in the samples were from 44 to 540 mg/kg, probably reflecting the presence of cryolite material, which was observed in the test pits. A summary of the metals concentrations detected in the CMSD samples, as compared to metals concentrations in natural soil is provided in Table ES-1.

Surface-water runoff via the seeps that discharge at the base of the CMSD is a potential pathway for migration of constituents from the CMSD. Analyses of surface water samples from the seeps that emanate from the base of the CMSD detected CLP total cyanide concentrations ranging from 0.163 mg/L to 0.950 mg/L, and cyanide amenable to chlorination from below detection to 0.549 mg/L. Fluoride levels in the CMSD seep samples were from 62 mg/L to 160 mg/L. Analyses of samples from Seep #2 and Seep #3 at the base of the CMSD detected Aroclor 1242 at concentrations ranging from 0.00083 mg/L to 0.0074 mg/L.

Water that discharges from the CMSD seeps flows overland a short distance to the 004 outfall stream. Because the CMSD is entirely underlain by low permeability silt and clay, the potential for impacts to ground water in the alluvial aquifer related to the CMSD is considered to be very low.

Plant Recreation Area Fill

Analyses of samples from Seep #1 and Seep #4, which are located along the base of the slope near the ballfield (see Figure 78), detected CLP total cyanide concentrations ranging from 0.0794 mg/L to 0.733 mg/L, with cyanide amenable to chlorination up to 0.0686 mg/L. Fluoride concentrations were from 6.5 to 92 mg/L. The pH of the ballfield seeps was up to 8.6. PCBs were not detected in the ballfield seeps.

As compared to concentrations reported for ground-water samples from the MW-19 background monitoring well, the concentrations of certain metals detected in Seeps 1 and 4 are higher. Cobalt was reported at 0.024 mg/L in the Phase I sample from Seep #1 and 0.052 mg/L in the Phase II sample from Seep #3, as compared to 0.0083 mg/L in MW-19. Sodium concentrations in the

ballfield seeps were from 945 mg/L to 3530 mg/L, compared to 32.2 mg/L in MW-19. Metals that were detected only in Seep #4 at concentrations above those reported in MW-19 include calcium (177 mg/L vs. 91.8 mg/L), chromium (0.023 mg/L vs. 0.0081 mg/L), magnesium (48.5 mg/L vs. 11.5 mg/L), manganese (31.1. mg/L vs. 0.230 mg/L), nickel (0.048 mg/L vs. <0.026 mg/L) and silver (0.018 mg/L vs. <0.0044 mg/L).

Ground Water

Ground-water flow and water-quality data obtained during the RI indicate the presence of a plume in the alluvial aquifer that emanates mainly form the vicinity of the former spent potliner storage area. This plume is characterized by a basic pH, ranging from 8.0 to 10.5, and above background concentrations of total cyanide (up to 18.2 mg/L total CLP), fluoride (up to 1000 mg/L), and sodium (up to 2640 mg/L).

From the area of origin, the plume moves with ground-water flow through a section of aquifer about 3000 feet long toward interceptor wells #1 or #2 and the Ormet Ranney well. By this flow condition, the plume body exhibits an elongate shape, with highest concentrations in the vicinity of the former spent potliner storage area (see Figures 108, 109, 110 and 111). As the plume is pulled through the aquifer toward the Ormet Ranney well and interceptor wells, concentrations decrease with distance from the source area. This trend is attributed mainly to mixing and possibly attenuation within the alluvial aquifer system.

Ground-water withdrawals by the Ormet and CAC Ranney wells have created two large cones of influence, one around each pumping center, which converge to form a gently rounded ground-

water divide that is situated roughly parallel and to the south of Ormet's southwest property boundary. By this condition, the plume in the alluvial aquifer is contained beneath the Ormet property, and a hydraulic potential does not exist for ground water beneath the Ormet plant to flow to the CAC Ranney well.

Certain metals appear to exhibit some relationship to the plume in the alluvial aquifer, including lead (two wells over 0.05 mg/L), aluminum (up to 178 mg/L), arsenic (up to 0.394 mg/L), chromium (up to 0.401 mg/L), cobalt (up to 0.814 mg/L), copper (up to 1.02 mg/L), nickel (up to 0.767 mg/L), beryllium (up to 0.035 mg/L), and vanadium (up to 0.369 mg/L). The occurrence of these metals in association with the plume potentially could be related to anthracite coal, which is a major component of potliner material. Analyses for non-CLP constituents indicate several alterations associated with the above-neutral pH condition. In particular, dissolved silica and TOC show generally increasing concentrations relative to increasing pH. Aluminum concentrations are also attributed to the basic pH condition. At a pH greater than 8, aluminum dissolved from the soils and aquifer materials can exist as $Al(OH)_4^-$, which increases its aqueous solubility.

PCBs were not detected in any of the ground-water samples. The only VOC that was reported at levels above the Contract Required Detection Limit (CRDL) was tetrachloroethene, at concentrations ranging from 0.005 mg/L to 0.040 mg/L. PAHs were not detected above the CLP CRDL in any of the ground-water samples analyzed. PAHs detected in ground-water samples using a special analytical procedure (developed by Ormet at the direction of USEPA and OEPA) with a 20 ng/L (parts per trillion) reporting limit are summarized in Table 77A and discussed in Section 4.2.

Surface Water

CLP volatile and semi-volatile organic compounds, including PAHs, are generally below the CRDL detection limit in the surface water. The only volatile organics reported were methylene chloride and acetone, which were reported in nearly all of the samples at values ranging from 0.001 to 0.002 mg/L and 0.008 to 0.020 mg/L, respectively. Three semi-volatile organics, fluoranthene, pyrene, and chrysene were reported in sample SW-5 from the 004 outfall backwater area, each below the CLP detection limit at an estimated concentration of 0.003 mg/L.

PCB Arochlor 1242 was reported in the SW-5 backwater sample, and the SW-9 sample immediately downstream from the backwater area (see Figure 81). The reported concentrations were 0.0015 and 0.0010 mg/L, respectively. The Aroclor 1242 detected at SW-5 and SW-9 is attributed to an oily film observed on the discharge from Seep #2 at the southwest toe of the construction material scrap dump. Samples from Seep #2 were also reported to contain Aroclor 1242 at a concentration of 3.6-7.4 mg/L.

Analysis of surface-water samples collected within and downstream of the backwater area (i.e., SW-5, SW-9, and the more downstream SW-12 locale) indicate water-quality characteristics attributable to the interceptor well water discharged through the NPDES-permitted outfall 004. These effects are evidenced mainly by above-background pH and concentrations of sodium, fluoride, and total cyanide. The highest values for pH (8.5), sodium (162 mg/L), and fluoride (12 mg/L) were reported for the SW-5 sample, which was taken from within the backwater area of the outfall discharge. With distance downstream from the backwater area, these parameters show a steady decrease to pH = 8.04, sodium = 52 mg/L, and fluoride = 3.3 mg/L at SW-9. At the SW-12 location,

the concentrations of fluoride (0.3 mg/L) and sodium (12.3 mg/L), and the pH (7.8) approach the background levels indicated in SW-1. The pattern of reported total cyanide concentrations is somewhat anamolous, in that, reported values are higher in the SW-9 sample (0.428 mg/L), immediately downstream of the backwater area, than in the SW-5 sample (0.125 mg/L) collected from within the backwater. In the SW-12 sample taken furthest downstream, total cyanide was reported at 0.0076 mg/L.

Of the CLP metals, data from SW-5 and SW-9 show some increases (relative to background) for dissolved arsenic (0.010 mg/L in SW-5 only), total (unfiltered) chromium (0.012 mg/L and 0.010 mg/L), total copper (0.026 mg/L and 0.016 mg/L), dissolved iron (0.812 mg/L and 0.357 mg/L), and dissolved manganese (0.726 mg/L and 0.349 mg/L).

Outfall 004 Backwater Sediments

The outfall 004 backwater area, situated immediately to the southwest of the construction material scrap dump, exists as a muddy shoal that extends southward to the Ohio River. The NPDES 004 outfall stream flows through the backwater area in route to the Ohio River (see Figure 81). Backwater sediments (as characterized by Phase I and Phase II samples from the RS-5 location or its duplicate sample analyses) reported total PAH concentrations ranging from 1122 to 1635 mg/kg and PCB Aroclor 1248 at 97.5 mg/kg (see Figure 83). The general indicator parameters detected at above background concentrations in the RS-5 backwater sediment samples are fluoride (up to 109 mg/kg), total CLP cyanide (42 mg/kg), and sodium (2060 mg/kg) (see Figure 82). CLP metals that were detected at higher concentrations in the RS-5 sample than in upriver (e.g., RS-1 background) samples

include calcium (32,500 mg/kg), magnesium (6,120 mg/kg), and copper (119 mg/kg) (see Figures 84, 85, and 86).

With the exception of methylene chloride and acetone (both at 0.032 mg/kg), no volatile organic compounds or semi-volatile organic compounds, other than PAHs, were reported above the CRDL in the RS-5 sediment samples.

Ohio River Sediments

Ohio River sediment samples were collected near the shore line of the river, adjacent to the Ormet site during both Phase I and Phase II. These included background samples (RS-1 series), samples from locations upstream from the backwater area but downstream from RS-1 (RS-2, RS-3, and RS-4 series), and samples from locations at the mouth of the backwater (RS-6) and downstream from this point (RS-7, RS-9, RS-12). River sediment constituents that appear to show a relationship to the backwater area include the following:

- Total PAHs, ranging from 26 to 176 mg/kg at RS-6 (at the mouth of the backwater), and dropping to 7 to 32 mg/kg at the downstream locations RS-9 and RS-12 (Figure 83);

- PCB Aroclor 1248 reported at 2.2 mg/kg at RS-6, 1.1 to 1.3 mg/kg at RS-9, and 1.0 to 2.5 mg/kg at RS-12 (Figure 83); and

- Fluoride and total CLP cyanide reported at RS-6 at 27 mg/kg and 1.6 mg/kg, respectively (Figure 82).

In river sediment samples RS-2 through RS-4, collected upstream of the backwater area and downstream of the background RS-1 location, total PAHs ranged from 7.7 to 25.6 mg/kg and PCB Aroclor 1248 was consistently below detection (Figure 83). The river sediment data give some

indication that higher values reported for barium, chromium, cobalt, copper, iron, lead, manganese, mercury, zinc, and nickel may tend to occur in the RS-2, RS-3, and/or RS-4 samples (Figures 84, 85, and 86).

With the exception of the reported detections of dimethylphthalate in RS-6 (0.52 mg/kg), 2-butanone in RS-3 (0.120 mg/kg), benzene in RS-2 (0.024 mg/kg), and methylene chloride in RS-1, RS-2, and RS-6 (0.037 to 0.049 mg/kg), no volatile organic compounds or semi-volatile organic compounds other than PAHs were reported above the CRDL in the Ohio River sediment samples.

Air

Based on physical characteristics and particle size distribution data, Pond 5 was identified as the only area at the Ormet site where wind erosion could result in significant emissions of respirable dust (i.e., particulate matter less than 10 μm in diameter - PM_{10}). To quantify the airborne transport of respirable dust from Pond 5, a modeling approach was utilized that takes into account a calculated wind-speed dependent emission rate. These emission rates and site-specific meteorological data were used to model PM_{10} concentrations that were measured at on-site air monitoring stations. The results of the air monitoring and air modeling tasks are provided in the Baseline Risk Assessment, which is included in Appendix R.

CAC Ranney Well

Sampling of the CAC Ranney well (see Figure 1) was conducted on June 22, 1990 and again on July 20, 1990. The samples for ground-water analyses were collected at the wellhead, before the

water has passed any of the treatment steps applied by CAC. The samples for drinking water analyses were collected from a point in the main distribution line immediately after CAC's treatment system, which includes chlorination.

CAC Ranney Well (Ground Water)

Two VOCs were reported in the ground-water samples and their field duplicates at concentrations above the CRDL, methylene chloride (0.005 mg/L to 0.014 mg/L) and acetone (0.039 mg/L and 0.043 mg/L). Four other VOCs were reported in the CAC Ranney well samples at concentrations at or below the CRDL, including 1,1-dichloroethane (0.001 mg/L), chloroform (0.002 mg/L to 0.005 mg/L), 2-butanone (0.002 mg/L), and 1,1,1-trichloroethane (0.002 mg/L). No semi-volatile organic compounds, pesticides, or PCBs were detected in any of the CAC Ranney well ground-water samples.

With regard to the main plume indicators for the Ormet site, the pH values for the CAC Ranney well samples were very consistent and near neutral (i.e., 7.2 to 7.3). Total cyanide and cyanide amenable to chlorination were not detected in any of the samples. Fluoride concentrations (0.3 to 0.8 mg/L) and sodium concentrations (18.8 mg/L to 20.3 mg/L) were within the natural range for the alluvial aquifer. By these data, there is no indication of any alternations to the water quality at the CAC Ranney well related to conditions at the Ormet site, reflecting the fact that a hydraulic potential does not currently exist for ground water beneath the Ormet plant to flow to the CAC Ranney well.

CAC Ranney Well (Drinking Water)

Of the inorganic drinking water parameters analyzed on the samples from the CAC Ranney well, only manganese was detected at concentrations (1.3 to 1.4 mg/L) above an existing drinking water standard (manganese has a secondary drinking water standard of 0.05 mg/L).

Five VOCs were detected in the drinking water samples from the CAC Ranney well, including 1,1,1-trichloroethane (0.002 mg/L to 0.00256 mg/L), cis-1,2-dichloroethene (0.0207 mg/L to 0.0228 mg/L), chloroform (0.00082 mg/L and 0.00096 mg/L), dichloromethane (0.00514 mg/L), and 1,1-dichloroethane (0.0012 mg/L to 0.00145 mg/L). Three VOCs, o-, m-, and p-dichlorobenzene, were detected in the field blank samples (concentrations from 0.0012 mg/L to 0.00497 mg/L) during both the June and July sampling events, but were not detected in the actual drinking water samples, indicating that these compounds are not associated with the CAC Ranney well.

The data generated during the RI indicates that the drinking water quality at the CAC Ranney is not being affected by conditions at the Ormet site.

Ormet Ranney Well

Sampling of the Ormet Ranney well (see Figure 1) was conducted during the Phase II RI, on February 23, 1990. A sample and a field duplicate were collected from a valve at the wellhead. The pH values of the ground water samples from the Ormet Ranney well were near-neutral, ranging from 7. 5 to 7.6. Of the other primary indicators of ground-water impacts at the Ormet site, fluoride was

detected at 1.3 mg/L; iron was reported at 0.1 mg/L in both samples; and CLP total cyanide concentrations were 0.0806 mg/L and 0.158 mg/L.

Baseline Risk Assessment

As required under current USEPA policy, the baseline risk assessment was prepared for the USEPA by a separate subcontractor. Also during the RI, the USEPA Environmental Response Team conducted an ecological survey of the Ormet site. The baseline risk assessment consists of a human health evaluation (Appendix R) and an environmental evaluation (Appendix R). By definition, the baseline risk assessment was limited to conditions under the no-action alternative. That is, an assessment in the absence of any remedial actions (excluding even the existing institutional controls) to control or mitigate releases. Most assumptions employed in the baseline risk assessment were more likely to overestimate than underestimate risk.

The baseline risk assessment included an evaluation of the large volume of monitoring data collected at the Ormet site to identify potential chemicals of concern (COC). An exposure assessment was performed to identify current and hypothetical future exposure scenarios. Maximum exposure pathways were quantified using the 95 percent upper confidence limit on the arithmetic mean of the monitoring data and modeled fugitive dust concentrations.

The analytical data collected during the RI was used to evaluate the baseline risks at the Ormet sites. Constituents of concern that were evaluated included 25 inorganic chemicals, 14 volatile organic chemicals, 23 semi-volatile organic chemicals, and PCBs. All the COCs did not contribute with equal significance to the quantified risks.

GERAGHTY & MILLER. INC.

Under current policy the USEPA considers excess lifetime cancer risks lower than 10^{-6} to be so small that they are of no practical significance, and excess lifetime cancer risks greater than 10^{-4} to be an indication that remediation is warranted. Risks between that range are evaluated on a site-specific basis during the risk management process. Non-carcinogenic hazards are evaluated as the ratio of the site-related dose to a USEPA verified reference dose, which is termed the hazard quotient. Acceptable non-carcinogenic effects are characterized by a hazard index (sum of hazard quotients for all COCs) of unity (one) or less.

The exposure pathways, risk levels, and COCs that contributed to risk levels as defined above are listed in Table ES-2. Other exposure pathways that were evaluated had excess lifetime cancer risks below 10^{-6} and hazard indices below one.

Under current land use conditions at the Ormet facility ingestion of fish from the Ohio River and exposure of a hypothetical trespasser to the sediments in the 004 discharge backwater and river were the only exposure pathways that resulted in excess lifetime cancer risks greater than 10^{-6} or hazard indices greater than one. The fish ingestion risk is based on one sample of river water collected in the vicinity of the 004 discharge, within an oil sheen. The concentrations of PCBs in this one river-water sample may be representative of only an isolated point and not the more general concentrations in the river that would influence fish tissue concentrations; therefore, considerable uncertainties exist in the calculation of the fish ingestion risks. There is no evidence that trespassers are currently accessing the Ormet facility in the area of the 004 discharge backwater or river bank areas; therefore, the risks calculated were for a hypothetical trespasser and not an existing receptor.

Table ES-2.   Summary of Potentially Significant Excess Lifetime Cancer Risks and Non-Carcinogenic Hazards, Ormet, Hannibal, Ohio.

Hypothetical Current Scenarios

Media	Receptor	Exposure Route	ELCR	HI	SCOC
surface water	hypothetical resident	fish ingestion	1E-1	--	PCB
sediments	hypothetical trespasser	ingestion/dermal	2E-4	--	PCB, PAH

Hypothetical Future Scenarios

Media	Receptor	Exposure Route	ELCR	HI	COC
soils	hypothetical resident	ingestion/dermal/inhalation	7E-3	2	As, Be, Cr, PAH, PCB
sediments	hypothetical resident	ingestion/dermal	3E-4	--	PCB, PAH
surface water	hypothetical resident	fish ingestion	1E-1	--	PCB
ground water	hypothetical resident	ingestion	2E-3	600	As, Be, CN⁻, F, Mn, PCE, V
ground water	hypothetical worker	ingestion	1E-3	30	As, Be, CN⁻, F, Mn, PCE, V

ELCR   Excess lifetime cancer risk
HI   Hazard index
SCOC   Chemicals of concern significant to risks
PCB   Polychlorinated biphenyl
PAH   Polynuclear aromatic hydrocarbon
As   Arsenic
Be   Beryllium
CN⁻   Cyanide
Cr   Chromium
F   Fluoride
Mn   Manganese
PCE   Tetrachloroethene
V   Vanadium

Future land use risks were characterized based on the assumptions that either: (1) the site remained an industrial facility but workers were exposed (via ingestion, handwashing, and showering) to the ground water because the existing interceptor wells were turned off; or (2) the Ormet facility is shut down and the site is converted to residential land use. Exposure pathways with risk levels of potential concern included ingestion of the ground water by the worker, and exposure of the resident to ground water, soils, surface water and sediments. Combining all the exposure pathways for the future hypothetical resident results in a risk level that is dominated by the PCB risk from ingestion of fish from the Ohio River. As discussed under the current land use conditions, the concentrations of PCBs detected in the one river-water sample may be unrepresentative of concentrations in the river, and the risks are probably overestimated.

Risks associated with exposure to lead were characterized using the USEPA biokinetic uptake model LEAD4. The calculated range of blood-lead levels for a hypothetical young child receptor population was 3.2 to 4.8 ug/dL, well below the acceptable guidance level of 10 ug/dL. Based on these results, lead is not a concern at the site.

In summary, exposure pathways of concern were identified for current and hypothetical future land use conditions at the Ormet facility. The assumptions employed in the baseline risk assessment were more likely to overestimate than underestimate risks. Consequently, it is unlikely that levels of risks at the site are higher than the levels calculated in the baseline risk assessment.

1.0   INTRODUCTION

In May 1987, the United States Environmental Protection Agency (USEPA), the Ohio Environmental Protection Agency (OEPA), and Ormet Corporation (Ormet) entered into an Administrative Order by Consent (Consent Order) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986. Under the Consent Order, Ormet was required, among other things, to conduct a remedial investigation (RI) to determine the nature and extent of any release or threatened release of hazardous substances, pollutants, or contaminants from the Ormet facility at Hannibal, Ohio.

Incorporated as part of the Consent Order was a Statement of Work (SOW), which outlined the tasks to be performed in conducting the RI and a subsequent feasibility study (FS) to identify and evaluate alternatives for the appropriate extent of remedial action, if any, to prevent or mitigate the migration of identified releases or threatened releases from the facility of hazardous substances, or of any pollutant or contaminant which may present an imminent and substantial danger to the public health or welfare.

As provided for in the Consent order, the RI was conducted in two phases. Field activities of the Phase I RI began in February 1988 and were completed in August 1988. The results of the Phase I RI were submitted to USEPA and OEPA in the form of a data report in October 1988. Based on the results of the Phase I RI, a scope of work for the Phase II RI was developed with the concurrence of USEPA and OEPA. The Phase II field activities were conducted from February 1990 through July 1990.

1.1 Purpose of Report

The purpose of this report is to address the following general objectives:

♦ Provide a historical summary of pertinent site activities;

♦ Present the results of investigative activities conducted during the RI;

♦ Summarize data and interpretations regarding the occurrence, extent, and migration of constituents in soils, waste materials, ground water, surface water, sediments, and air that may pose a potential threat to human health and/or the environment;

♦ Summarize the environmental fate and transport mechanisms for the constituents detected at the Ormet site; and

♦ Present the results of the Baseline Risk Assessment that was performed to evaluate the potential for adverse effects to human health and the environment in the event of exposure to conditions at the site.

1.2 Report Organization

This report was prepared in accordance with the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988a), and is comprised of seven main sections. These sections and a brief description of the material contained in each are as follows:

1.0 - Introduction

The introduction provides the objectives of the report and a description of site background conditions and previous site investigations.

2.0 - Study Area Investigations

This section describes the investigative tasks that were conducted during the RI, including the sample collection locations, the number of samples collected, and the parameters that were analyzed. Also, the tables that contain the analytical data from the various tasks are referenced in this section.

3.0 - Physical Characteristics of the Study Area

Descriptions of pertinent physical surface and subsurface features and media at the site are presented. Included are descriptions of important surface features, the meteorology of the study area, site geology, hydrogeology/hydrology, ecology, and surrounding land use. The majority of the discussions in this section are based on data and direct observations from the RI, as supplemented with available information from other sources.

4.0 - Nature and Extent of Contamination

This section presents data and interpretations regarding the occurrence of contaminants at the Ormet site, the extent of the affected areas(s), and current and potential future trends in contaminant migration. Included are discussions of the relationship(s) between the plume of altered ground water beneath the site and the associated source area(s).

5.0 - Contaminant Fate and Transport

This section describes the environmental fate and transport mechanisms for the contaminants that have been detected at the Ormet site during the RI, which may pose a potential threat to human health or the environment in the event of exposure to conditions at the site.

6.0 - Baseline Endangerment Assessment

Various current and potential exposure scenarios are identified and, using data from the RI, the potential risk associated with exposure to conditions at the Ormet site is evaluated. In addition, an assessment of the potential for impacts to the environment due to conditions at the site will be presented. A Baseline Risk Assessment conducted by USEPA is incorporated in the RI Report.

7.0 - Summary and Conclusions

Major interpretations regarding the nature, extent, and migration trends of contaminants detected during the RI are summarized. In addition, conclusions as to

the potential for adverse health and environmental effects in the event of exposure to conditions at the Ormet site are presented.

In addition to the text sections, this report also includes numerous data tables and figures to aid in evaluations of relevant trends. Presented in the tables are the analytical data that have been generated during the RI, and other types of numerical data. All laboratory data that were generated using USEPA Contract Laboratory Program (CLP) protocols have been validated according to the USEPA Laboratory Data Validation Functional Guidelines (USEPA, 1988b). Also part of this report are Appendices A through O, which contain various types of supporting data and documentation, such as boring logs, well construction logs, sampling logs, photographs, descriptions of field methodologies, and CLP data validation worksheets. For convenience and easy reference while reviewing the text of the report, the tables and figures have been provided in a separate document and the appendices have been combined in another.

1.3   Site Background

1.3.1   Site Description

The Ormet facility in Monroe County, Ohio is situated along the west bank of the Ohio River, approximately 35 miles south of Wheeling, West Virginia and about 3 river miles upriver from Hannibal, Ohio. This corresponds to river mile 123.4, which is the distance downriver from the origin of the Ohio River in Pittsburgh, Pennsylvania. The Ormet property occupies the northeastern portion of the area known as Buck Hill Bottom, a lens-shaped stretch of land approximately 2.5 miles long and up to 0.5 miles wide (see Figure 1). The Ormet property is bounded on the northwest by Ohio State Route 7 and on the east and southeast by the Ohio River. To the southwest, the site is bordered by the Consolidated Aluminum Corporation (CAC) facility, which occupies the southwestern portion of Buck Hill Bottom.

1.3.2   History of On-Site Waste Treatment, Storage, and Disposal

1.3.2.1   Spent Potliner Storage and Treatment

Since beginning plant operations in 1958, Ormet's main process has been the reduction of alumina to produce aluminum metal by the Hall-Heroult process. In this process, alumina is placed in an electrolytic bath contained in a series of electrolytic cells, or pots, and is reduced to aluminum. The pots are lined with prebaked blocks of a mixture of anthracite and pitch which are joined with a small amount of similar material and baked in-situ. This potliner eventually deteriorates to a point at which it must be removed and the cell is relined.

Potlining failure is caused by the carbon portion of the liner becoming impregnated with fluoride-containing salts. The salt in the molten electrolyte is predominantly cryolite. As the ingress of cryolite continues, the integrity of the lining is adversely affected. This material will actually intercalate within the crystalline lattice of the carbon materials, causing distortion and stress within the lining. The insulating materials are similarly effected and become thermally conductive as they are impregnated by these fluoride salts. Failure can occur by cracking or excessive heaving of the lining.

When these failures occur, trace amounts of cyanide are formed due to the ingress of air and subsequent reaction of nitrogen in the air with the carbonaceous portion of the lining under the extreme heat of the reduction process. The cyanides formed are predominantly iron-complexed, with some simple cyanide. This ingress of air continues and cyanide continues to be formed, until the lining completely fails and must be removed from service to prevent the molten aluminum from burning through the steel metal shell. In some cases, this burn through occurs before the pot is removed from service.

Cyanide is not formed in the anodes because the anodes are exposed to large amounts of air and are actually consumed in the reduction process. Similarly, because cyanide is not a constituent of the air emissions from the process, there is no cyanide associated with residual material from air pollution control systems, such as wet scrubber sludge.

It is estimated that, from 1958 to 1968, approximately 85,000 tons of spent potliner material were placed in an unlined open storage area (approximately 10 acres) located in the northeast portion of the Ormet property (see Figure 2). The potliner material forms the cathode section of the

reduction process in each pot (or cell) and is composed predominantly of anthracite coal and electrode pitch binder that is pre-baked. Potliner also contains portions of sodium-aluminum fluoride (cryolite), alumina (Al_2O_3) and some fire brick. The spent potliner is generated when the molten aluminum metal burns through the potliner and comes in contact with the steel cell wall. The spent potliner is then removed from the pot using a jackhammer and the cell is relined.

From 1968 to 1981, Ormet operated an on-site cryolite-recovery plant in the southeast corner of the active facility (see Figure 2). The recovery plant utilized caustic digestion to recover cryolite from the spent potliner. In this process, crushed potlining was slurried in the ball mill with weak caustic to begin the extraction process. The slurry was stored in three 48,000 gallon tanks. From the slurry tanks, the slurry was sent to the digestion tank, where live steam consisting of 2 to 3 percent steam and 50 percent caustic were used to extract fluoride and alumina (as sodium aluminate) at 210 degrees Fahrenheit. From the digester, the slurry was sent to the #1 thickener, where the undissolved carbon, alumina, and other insolubles were separated from the fluoride/aluminate-rich liquor. This liquor was then pumped to the carbonators, where the sodium fluoride and aluminate were reacted with carbon dioxide to form cryolite. The solids from the #1 thickener were sent to the mud wash thickener, where additional fluoride was recovered by rinsing the solids with water. The remaining solids became the tailings, which were pumped to Pond 5. Beginning in 1971, chlorine was added to the tailings to destroy cyanide amenable to chlorination. Beginning in 1975, the tailings were neutralized by adding sulfuric acid prior to being pumped to Pond 5.

When the cryolite-recovery plant was put into operation, all spent potliner generated during the period of its operation was processed at the cryolite recovery plant. In addition, heavy equipment was used to load the potliner from the former spent potliner storage area into trucks for transport to

the cryolite-recovery plant for processing. Due to the nature of the operation (i.e., use of heavy equipment) a small portion of the potliner material was broken and crushed and became mixed with the underlying soils. Because the residual potliner material is intermixed and/or interlayered in the shallow soil, it is virtually impossible to arrive at an accurate estimate of the volume of actual potliner material that may still be present within the former potliner storage area. Based on surface geophysical surveys and a subsequent soil boring and analysis program that were performed as part of Geraghty & Miller's Supplemental Hydrogeologic Investigation (1986), and also on the results of the Phase I RI soil boring and analysis program (see Section 2.2.2), it is estimated that the area of soil which may have been in contact with the former spent potliner is on the order of 10 acres. A more detailed discussion of the physical and chemical character of the former potliner storage area is presented in Section 4.1.

Through utilization of the cryolite-recovery process, almost all (≥95%) of the spent potliner material in the former storage area was eliminated. During November 1980, the remaining spent potliner in this area was transported off-site for disposal. Since the shutdown of the cryolite-recovery plant in the fall of 1981, all spent potliner has been transported off-site for disposal. Since 1979, interim accumulation of spent potliner material has been under cover on a concrete pad.

1.3.2.2   Former Disposal Ponds

At various times from 1958 to 1981, Ormet utilized one or more of the five retention ponds (Ponds 1 through 5) located in the northeastern portion of the facility (see Figure 2). These ponds were constructed of natural materials and did not include synthetic liners; although, a portion of Pond 3 and much of Pond 5 are directly underlain by natural deposits of silt and clay. The geology beneath

the former disposal ponds is described in more detail in Section 4.4.1. When in use, Ponds 1 through 4 received sludge from the pot-room wet scrubbing system and/or the wet scrubber for the anode bake furnace. The primary constituents of this sludge were alumina, particle carbon, and calcium-based salts. Pond 5 was put into service to receive tailings from the cryolite-recovery plant when it began operation in 1968. Ponds 1 through 4 may have also received some minor amount of tailings from the cryolite recovery plant. These alkaline cryolite tailings consist primarily of carbonaceous material from the potliner after its has been treated by the caustic digestion process in the cryolite plant. In addition to particle carbon and alumina, these alkaline cryolite tailings contained sodium-based salts, as well as some calcium salts.

Ponds 1, 2, and 3 are from about 1.1 to 1.2 acres in size. The depth of Ponds 1 and 2 ranges from a minimum of about 3.9 feet to a maximum of about 7.8 feet. The depth of Pond 3 ranges from a minimum of about 11.7 feet to a maximum of about 13.7 feet. Pond 4 is about 1.9 acres in size and ranges from 5.7 to 11 feet deep. Pond 5 covers approximately 13 acres and ranges in depth from a minimum of 8.3 feet to a maximum of more than 28 feet deep. The combined volume of the material contained in the five former disposal ponds is estimated to be on the order of 420,000 cubic yards, with Pond 5 accounting for around 370,000 cubic yards. Each pond is surrounded by a dike that consists predominantly of clay and silt, with varying proportions of sand, gravel, rock fragments, and fill material (e.g., brick). A more detailed description of the physical and chemical characteristics of the five former disposal ponds is provided in Section 4.1.

1.3.2.3 Construction Material Scrap Dump

From time to time prior to 1980, Ormet deposited waste construction materials and other miscellaneous plant debris and waste in the southeastern corner of the Ormet property, adjacent to Pond 5. This area has been designated as the construction material scrap dump (CMSD) which covers approximately 4 to 5 acres and is generally depicted on Figure 2.

Based on discussions with long-term employees and a review of available aerial photographs, it appears that the area currently designated as the CMSD received material from plant operations from about 1966 until mid-1979. During this entire period of time, an independent contractor was conducting a salvage operation to recover recyclable and reusable items from the plant-generated material. During this period, materials not recycled by the contractor were placed in the CMSD.

Given below is a general summary of material generated at the Ormet plant during this period of time. This listing is based on discussions with plant personnel, available aerial photographs, and the results of reconnaissance surveys and test-pit activities conducted during the RI. However, it is not known whether all of these materials were disposed of in the CMSD.

Furnace brick (e.g., anode furnace, electromelt furnace, cast house furnace)
Wooden pallets
Petroleum coke fines and anode production scrap
Miscellaneous demolition debris (e.g., concrete, steel, wood, glass, aluminum siding, pipe, roofing material, insulating materials)
Petroleum products (e.g., hydraulic oil, motor oil, press oil, solvent)
Plant trash (e.g., paper, cardboard, packaging materials, paint cans)
Discarded electrical components (e.g., light ballasts, capacitors, circuit breakers)
Motor shop wastes (e.g., tires, brake pads, antifreeze, batteries)
Discarded mechanical components (e.g., belts, gears, hoses, valves, cable)
Discarded fugitive raw material (e.g., alumina, cryolite and anode binder pitch)
Spent potliner

The salvage contractor removed selected items from the plant material for resale or recycling. Materials removed by the contractor commonly included the following:

    Scrap steel/aluminum (including empty drums)
    Drummed petroleum products
    Batteries
    Antifreeze

In addition, combustible materials were burned at the site for volume reduction, until such practice was prohibited by applicable air emission rules.

In 1979, the perimeter of the CMSD nearest to the river was pulled back onto the top of the CMSD and leveled to its current configuration. Since that time, the CMSD has not received waste material from the plant. During the RI, tasks were conducted to directly characterize the materials in the CMSD (see Section 2.2.3). The results of these investigations are discussed in Section 4.1.4.

1.3.2.4   Carbon Runoff and Deposition Area

The carbon runoff and deposition area is described as the wooded area of the plant site bounded on the west by the toe of the slope below the plant fence line between wells MW-3 and MW-40, on the east by the toe of the CMSD, on the north by the fence line south of Ponds 1 and 2, and on the south by the Ohio River (see Figure 2). The deposits of carbon material in this area cover about 3 acres and range from less than one foot to approximately five feet thick. It appears that the carbon material was carried into this area by stormwater runoff from the area of the anode crushing mill (see Figure 2). Some of the carbon runoff material may also have entered the 004 outfall stream and backwater area. A more in-depth discussion of the physical and chemical characteristics of the carbon runoff and deposition area is presented in Section 4.1.3.

1.3.3   Previous Investigations

1.3.3.1   Enforcement Actions

Prior to the current RI/FS being conducted under CERCLA, Ormet had not been directed by any local, state, or Federal Agencies to take any CERCLA response action at the Ormet plant in Hannibal, Ohio. However, Ormet had retained consultants to perform a series of hydrogeologic investigations for the purpose of identifying potential sources of ground-water contamination and to develop appropriate remedial alternatives. These site activities are summarized in the following paragraphs.

1.3.3.2   Early Studies

♦ Changes in the quality of water produced by the Ormet Ranney well prompted site hydrogeologic studies (Klaer, 1972) to assess water-quality conditions and ground-water flow patterns beneath the facility. The Ranney well is located in the southwestern corner of the Ormet facility (see Figure 2) and supplies water used in the manufacturing process, mainly for non-contact cooling. The studies included the installation of 20 monitoring wells (TH-series). The TH-series wells that are still present at the Ormet site (6 total) are shown in Figure 2. Resultant data indicated that fluid was mounded beneath in then-active Pond 5 and that affected ground water was being pulled from beneath the disposal ponds and potliner storage area toward the Ormet Ranney well. At the time of the Klaer study, fluoride concentrations in monitoring wells in the vicinity of Pond 5 and the potliner storage area typically were in the range of 300 to 700 mg/L. At a monitoring well that was near the

existing MW-31 well (see Figure 2), fluoride concentrations of 550 and 1260 mg/L were reported. As a result of this investigation, two interceptor wells (#1 and #2) were installed approximately two hundred feet north of the Ormet Ranney well (see Figure 2) to intercept the plume before it reached this pumping center.

These interceptor wells are each about 100 feet deep and are screened into the alluvial aquifer. They are each constructed of 14-inch diameter steel casing coupled to 13-inch diameter, 10-foot long 0.100-inch-slot screen sections. The wells are each equipped with 15 horse power turbine pumps and are pumped non-concurrently at a rate of about 230 gpm. The purpose of these interceptor wells is to "intercept" the ground-water plume prior to reaching the Ormet Ranney well in order to preserve the quality of this Ormet process water supply. Water from interceptor well #1 and #2 is discharged to the NPDES-permitted 004 outfall (see Figure 2).

♦ Water-quality data collected during a supplemental study (Dames and Moore, 1978) indicated improvement in the quality of ground-water in the vicinity of Pond 5. Water-quality data collected by Dames & Moore also suggested that ground water beneath the former spent potliner storage area had become slightly more contaminated (see Geraghty & Miller, 1984a, which is provided as an appendix to the Phase I RI Work Plan). This interpretation is based primarily on a comparison of the fluoride concentrations reported by Dames & Moore to those reported by Klaer for monitoring wells TH-10 and TH-11, which were located in the former spent potliner storage area. Klaer (1972) reported fluoride concentrations in these wells that ranged from 0.9 to 10.0 mg/L and from 1.4 to 10.0 mg/L respectively. Dames & Moore (1978) reported fluoride concentrations in TH-10 that ranged from 43.4 to 48.3 mg/L and a concentration of 8.6 mg/L in TH-11.

◆ In March, 1982, Interceptor Well 3 was installed adjacent to the northwest corner of Pond 5 (see Figure 2), in an effort to collect contaminated ground-water before it migrated toward the Ranney well. In June 1989, the operation of Interceptor Well 3 was discontinued with the concurrence of USEPA and OEPA, as it was demonstrated that pumping of this well had no substantive effect on the flow of ground water beneath the site or the migration of the plume beneath the former spent potliner storage area.

1.3.3.3   Recent Studies

◆ Geraghty and Miller, Inc. was retained by Ormet in October 1983 to conduct a detailed hydrogeologic investigation at the Hannibal facility. The purpose of the study was to better define the source(s) and the nature and extent of the ground-water contamination, and to identify possible remedial alternatives to abate existing and potential conditions. The 1983 Geraghty & Miller study included the installation of nineteen additional monitoring wells. Based on the results of this study (Geraghty & Miller, 1984a), Geraghty & Miller concluded that there is no apparent natural discharge of ground water from the alluvial aquifer to the Ohio River along Ormet's river/plant boundary due to the drawdown in the water table created by the pumping of the Ormet Ranney well. Geraghty & Miller also concluded that the plume is contained within Ormet's facility boundaries by pumping of the Ormet Ranney well and interceptor wells. Water-quality data collected during this study suggested that the ground-water contamination related to Pond 5 had become greatly reduced since the 1972 study and that the existing ground-water conditions were due primarily to leachate generated from within the former potliner storage area. The reduction in the level of ground-water contamination related to Pond 5 was attributed to the decommissioning of the pond in 1981, when Ormet ceased operation of the cryolite recovery plant.

◆ Following the 1983 study (Geraghty & Miller, 1984a), Geraghty & Miller continued to sample, analyze, and evaluate ground water from the nineteen monitoring wells. These subsequent sampling and analysis programs were performed during September 1984 and May 1985. The results of these monitoring events indicated ground-water flow patterns consistent with those previously mapped and possible slight improvements in plume quality (Geraghty & Miller, 1984b and 1985).

◆ In October 1985, Geraghty & Miller performed a supplemental ground-water sampling and analysis program that included selected monitoring wells, Interceptor Well #1 and the 004 outfall (see Figure 2). This work included analyses for Priority Pollutant organic compounds. Toluene was the only organic compound that was detected in these samples, at levels at or near the detection limit (Martell, 1985). The reported concentrations ranged from 9 to 15 ppb.

◆ Ormet directed Geraghty & Miller in February, 1986 to identify and conceptually develop feasible remedial alternatives to minimize source-area-related contributions and to restore ground-water conditions. This work included surface geophysical surveys to identify possible source areas and plumes of contaminated ground water; soil boring and analysis programs in both the former potliner storage area and the retention ponds to assess the physical nature and chemical make-up of potential source materials; installation of 30 additional monitoring wells at a total of 20 locations, designated MW-21 through MW-40, (see Figure 2); and ground-water monitoring to further define ground-water flow patterns, to characterize the chemical make-up of leachate plumes, and to further assess plume/source-area relationships.

Field work conducted under this investigation was completed prior to the initiation of the present CERCLA-related activities. Because of the pending CERCLA activities, the findings from

GERAGHTY & MILLER, INC

this supplemental work were not summarized in a formal report, but were included in the Appendix

B of the Phase I RI Work Plan. These data were not collected under the supervision of USEPA, but

were collected using standard industry practices and were used to design the RI/FS SOW attached to

the Consent Order.

2.0   STUDY AREA INVESTIGATIONS

2.1   Surface Features

On April 20, 1987, Kucera International of Mentor, Ohio conducted on aerial photographic survey of the Ormet Corporation site. From this survey, a topographic base map of the site was constructed at a scale of one inch equals 50 feet and with a contour interval of one foot. The resulting map consists of 15 separate plates, which are provided as Appendix A of this report.

Throughout the text of this report, pertinent site features and remedial investigation sample collection locations are presented on generalized site maps for quick reference. These locations, as determined by a licensed surveyor, are more accurately plotted on the topographic base map in Appendix A.

2.2 Investigations of Potential Source Areas

2.2.1 Disposal Pond Waste Characterization

During Phase I of the RI, solids samples were collected at a pre-determined number of lateral locations and from several depth intervals within the pond solids/sludges at each location within the five former disposal ponds on the Ormet property. Four sampling locations were situated in each of Ponds 1, 2, and 3. Pond 4 was divided into two sections and Pond 5 into five sections, with four sampling locations in each section. The general locations of each of the pond solids sampling points are shown on Figure 3. The sampling locations, as measured by Geraghty & Miller personnel, are provided on Sheets 11 and 12 of Appendix A. The sampling locations were determined by triangulation. That is, a 200-foot nylon measuring tape was used to measure from each sampling point on the pond surface to at least two points on the pond berm (i.e., pond perimeter borings and/or monitoring wells) which had been located by a licensed surveyor (see Appendix B). A description of the characteristics of the pond surfaces is included in Section 4.1.1

Prior to beginning the sampling program, a 20-foot piece of steel reinforcing rod (rebar) was used to sound the depth of the pond solids/sludges at each location. These data were then used to determine the appropriate sampling intervals for each pond or pond section and also in the final design of the sampling instrument. The sampling intervals for each pond and pond section are given in Table 1.

Samples from similar depth intervals in each pond or pond section were composited, with samples from the sludge/soil interface always being composited, regardless of the sampling depth.

Due to variations in the topography of the sludge/soil interface, there were several instances where the composite samples from the interval immediately above the interface interval did not include samples from all four locations in that pond or section. These cases are noted in Table 1.

Based upon the sounding data, the depth of the solids/sludges at many of the proposed sampling locations in Pond 5 was found to exceed 20 feet; therefore, a sampling interval from 20 to 23 feet was initially anticipated to intercept the sludge/soil interface. However, in the first section to be sampled in Pond 5 (Section E), this interval was found to intercept the sludge/soil interface at only one location. Based upon this finding, the approach to sampling the Pond 5 interface was modified. At those locations where sounding with the reinforcing rod indicated a depth greater than 20 feet, samples were collected from a depth of 25 feet down to the interface, or to a depth of 28 feet, whichever was encountered first. If the interface was encountered before reaching the 25-foot depth, the sample was collected from the three-foot interval immediately above the interface. Because only one of the initial samples collected from the 20 to 23-foot interval in Section E of Pond 5 encountered the interface, this section was resampled using the modified approach. Table 2 provides a summary of the depth intervals from which interface samples were collected for each of the sampling points on Pond 5. Figure 3 shows the depths of the disposal ponds at each of the sampling locations, as determined from the sounding/sampling program. Using these pond solids depth data, isopach (thickness) maps of the pond materials were prepared for each disposal pond. These maps are presented in Figures 4 through 7.

At several pond-sampling locations, samples from the interface included some of the underlying soil material. This material was not included in the sample composite that was submitted

to the laboratory for analyses, but was described for general composition and physical appearance. This information is summarized in Table 3.

The methodology that was used to collect the disposal pond solids samples is described in Appendix C-1. A total of 47 pond solids samples (41 samples and 6 field duplicates) were submitted for laboratory analyses, along with six field replicate samples. The samples were analyzed for a list of parameters given below.

PARAMETERS ANALYZED FOR ON

DISPOSAL POND SOLIDS SAMPLES

pH	% Solids
Ammonia-nitrogen	Total Organic Carbon
Fluoride	Alkalinity
Silica	Chloride
Cyanide (total)	Sulfate
Cyanide (amenable to chlorination)	

Organic and inorganic parameters of the USEPA CLP program, excluding pesticides and 2,3,7,8 dioxin.

The resulting analytical data are presented in Tables 4 through 12. Summaries of the volatile and semi-volatile organic compounds detected in the pond solids samples are provided in Tables 13 and 14, respectively. The samples were designated according to the pond and section (where applicable) from which they were collected, along with the depth interval (e.g., 5A-10-13). Graphs depicting variations in the concentrations of selected parameters with depth in the disposal ponds are provided in Figures 8 through 47.

To determine the relative permeability of the surface of each of the former disposal ponds, one double-ring infiltrometer test was conducted near the center of each pond or pond section. These tests were carried out according to ASTM Method 3385-75 (ASTM, 1985), which is provided as Reference 1 to Section 3 of the Phase I RI Work Plan. Table 15 provides a summary of the infiltration velocities obtained from this testing. The results of these tests provide a characterization of the permeability of the uppermost portion of the pond solids and may have no correlation with infiltration velocities below the surface of the ponds. Consequently, the results of the infiltrometer tests cannot be used to predict the velocity of water or dissolved solids movement through the pond solids. Additional data from the infiltrometer tests are contained in Appendix D.

2.2.2 Former Waste Potliner Storage Area Characterization

During Phase I of the RI, the former potliner storage area was gridded off into two-hundred by two-hundred-foot sections (24 sections total). At the center of each section, a soil boring was advanced to a depth of ten feet. A description of the methodology that was used to conduct the soil boring program is provided in Appendix C-2. Boring logs for these soil borings are provided in Appendix E. The general locations of the borings are shown in Figure 48, while the locations, as determined by a licensed surveyor, are plotted on Sheets 7, 8, 11 and 12 of Appendix A. The tabulated survey data, including plant coordinates and ground-surface elevations for each boring are listed in Appendix B.

At each boring location, split-spoon samples were composited over two-foot intervals, so as to create five composite soil samples for each boring. The composite samples, 120 in all, and twelve field replicates were analyzed for six parameters that are indicative of effects related to potliner

material, including calcium, sodium, fluoride, ammonia-nitrogen, pH, and total cyanide. Results of these analyses are provided in Table 16.

For each of the indicator parameters and each two-foot composite interval, an equal concentration contour map was prepared for the former potliner storage area. These isopleth maps are presented in Figures 49 through 73.

Based upon the results of the indicator parameter analyses, samples from each depth interval in each of four borings (20 samples total) were analyzed for the organic and inorganic parameters of the USEPA CLP List, excluding pesticides and 2,3,7,8 dioxin. These analytical data are contained in Tables 17 through 20. A summary of the semi-volatile organic compounds detected in the soil samples is given in Table 21.

2.2.3   Construction Material Scrap Dump Characterization

During a site visit conducted by USEPA and OEPA on November 20, 1986, two seeps were identified along the base of the construction material scrap dump (CMSD) and a steel conduit was located extending from the Pond 5 dike along the Ohio River. The general locations of these seeps (designated as seep #2 and #3) and the steel conduit are shown on Figure 74.

During the Phase I RI, these seeps and conduit were sampled and analyzed for a list of parameters specified by the Agencies, which is shown below.

PARAMETERS ANALYZED FOR ON

PHASE I AND PHASE II SEEP SAMPLES

pH (field and laboratory)   Fluoride
Specific Conductance   Sulfate
  (field and laboratory)   Cyanide (total)
Ammonia-nitrogen   Cyanide (amenable to chlorination)
Total dissolved Solids
Total organic Carbon
Alkalinity
Chloride

Organic and inorganic parameters of the USEPA CLP program.

The results of these analyses are contained in Tables 22 through 26.

During a site visit conducted by USEPA and their oversight contractor on January 30, 1990, three additional seeps, designated #5, #6, and #7, were identified along the base of the CMSD (Figure 74). As part of the Phase II RI, two of these seeps (#5 and #6) were sampled (#7 was dry) and analyzed for a list of parameters shown above. In addition, seep #2 and #3 were re-sampled and analyzed for the same list of parameters, to confirm the Phase I results.

Analytical data from the Phase II seep sampling program are presented in Tables 22 through 26. Water Sampling Logs completed during the collection of the Phase I and Phase II seep samples are included in Appendix F. A description of the methodology used to collect the seep samples is provided in Appendix C-3.

Also as part of the Phase II RI, activities were undertaken to generally characterize the contents of the CMSD. Using historical aerial photographic and information obtained through

interviews with senior plant employees, a memorandum (Ormet, 1990) was prepared describing the general disposal history of the CMSD and the types of materials that may have been placed in the CMSD. Information from the memo has been included in Section 1.3.2.3. The memo is provided in Appendix G.

During the Phase II field program, a reconnaissance of the perimeter of the CMSD was performed. During the reconnaissance, the material exposed on the face of the dump was described and photographed. Photographs from the perimeter reconnaissance, along with the associated descriptions of the material exposed, are provided in Appendix H.

In addition, test pits were excavated at four locations within the CMSD. The locations of the test pits (see Figure 75) were selected with the concurrence of USEPA and their oversight contractor. The test pits were to be excavated to a depth of 15 feet or until natural soil was encountered, which ever occurred first. Natural soil was not encountered in any of the pits, so each test pit was excavated to a depth of approximately 15 feet. The material from each two-foot interval was spread next to the excavation, described, and photographed. Also, a representative sample of material was collected from each two-foot interval and composited to form one composite sample for each test pit. These samples were analyzed for the list of parameters given below.

PARAMETERS ANALYZED FOR ON
CONSTRUCTION MATERIAL SCRAP DUMP SAMPLES

% Solids	Sulfate
pH	Total Organic Carbon
Ammonia-nitrogen	Cyanide (total)
Chloride	Cyanide (amenable to chlorination)
Fluoride	

Organic and inorganic parameters of the USEPA CLP program.

It should be noted that the samples analyzed for VOCs were not composites, but were grab

samples collected from discrete depth intervals. The result of these analyses are presented in Tables

27 through 31. A summary of semi-volatile organic compounds detected in the CMSD samples is

provided in Table 32. During the excavation of test pit #2, water was encountered at a depth of

about 11 feet. A grab sample of the water in the pit was collected and analyzed for PCBs using

Method 8080. These data are presented and discussed in Section 4.1.4. Photographs and descriptions

of the material excavated from the test pits are provided in Appendix I.

The locations of the CMSD seeps and test pits, as determined by a licensed surveyor, are

plotted on sheet 15 of Appendix A. The survey data, including the plant coordinates and land surface

elevations of the seeps and test pits are listed in Appendix B. A description of the methodology used

in the test-pit operation is provided in Appendix C-4.

2.2.4   Carbon Runoff and Deposition Area Characterization

At the outset of Phase I of the RI, the carbon runoff and deposition area was described as the

wooded area of the plant site bounded on the west by the toe of the slope below the plant fence line

between wells MW-3 and MW-40, on the east by the 004 outfall stream, on the north by the fence

line south of Ponds 1 and 2, and on the south by the Ohio River.

To assess the horizontal and vertical extent of these carbon deposits, the entire wooded area

was gridded off into 50 by 50-foot sections. As part of the Phase II, the grid was extended to the

east, into the area between the 004 outfall stream and the base of the CMSD. The general

configuration of the carbon runoff area sampling grid is shown in Figure 76. A more detailed plot

of the sampling grid is shown on sheets 14 and 15 of Appendix A.

At each grid-line intersection, a shallow hand boring was performed to determine the

thickness of the carbon material and to characterize the underlying soil. The sample descriptions from

the grid sampling program are included in Appendix J. Data concerning the thickness of the carbon

deposits were used to construct an isopach map of the carbon material (Figure 77). The thickness of

the carbon materials ranges from less than 0.1 foot to a maximum of 5.2 feet. During the Phase I

carbon runoff area sampling program, samples of the carbon material and underlying soil were

collected at six locations (Figure 76) and analyzed for a list of parameters shown below.

PARAMETERS ANALYZED FOR ON

CARBON RUNOFF AREA SAMPLES

% Solids	Sulfate
pH	Silica
Alkalinity	Total Organic Carbon
Chloride	Cyanide (total)
Fluoride	Cyanide (amenable to chlorination)

Organic and inorganic parameters of the USEPA CLP program.

(excluding pesticides, PCBs, and 2,3,7,8 dioxin).

The results of these analyses are contained in Tables 33 through 39. Summaries of volatile and

semi-volatile organic compounds detected in the carbon runoff area samples are provided in Tables

40 and 41, respectively. The soil samples were collected from the interval from about one foot to

about two feet below the bottom of the carbon material. The carbon runoff samples were designated according to the sampling location (e.g., CRA-B2), followed by a 'C', which indicates a sample of carbon material, or an 'S', which indicates a sample of underlying soil. A description of the methodology used in the carbon runoff area sampling program is provided in Appendix C-5.

2.2.5 Plant Recreation Area Waste Investigation

During a site visit conducted by USEPA and OEPA on November 20, 1986, two seeps (#1 and #4) were identified at the base of the slope leading down to the Ormet baseball field (Figure 78). During the Phase I RI, these seeps were to be sampled. However, because the seeps were sampled in mid-summer, only one (#1) was yielding sufficient flow to be sampled. The Phase I seep sampling was conducted on July 7, 1988 and the weather was hot and dry. During the Phase II RI, both seeps yielded adequate flow to permit sample collection. The Phase I and Phase II seep samples were analyzed for a list of parameters that included organic and inorganic parameters of the USEPA CLP list, cyanide (amenable to chlorination), and other general water-quality parameters. The results of these analyses are contained in Tables 22 through 26.

The locations of the seeps, as determined by a licensed surveyor, are plotted on Sheet 8 of Appendix A. The survey data are included in Appendix B. The procedures used to collect the seep samples have been described in Appendix C-3 and the Water Sampling Logs completed during the collection of the seep samples are included in Appendix F.

In addition to the sampling and analysis of the seeps, three soil borings were drilled in the recreation area during Phase I to assess the physical composition and extent of an area of fill material

on the slope below the horseshoe area. One soil boring was drilled in the horseshoe area and two were drilled on the baseball diamond in a line roughly parallel to the Ohio River (see Figure 78). All three borings were drilled to a depth at least five feet into natural soils using the procedures described in Appendix C-7. Soil samples were described in the field for gross composition, texture, relative degree of saturation, and other observable physical properties. Boring logs for the recreation area soil borings are provided in Appendix K. Surveyed locations of the borings are plotted on Sheet 12 of Appendix A and the associated survey data are listed in Appendix B.

2.3   High-Volume Air Monitoring Study

As part of the RI, Energy and Environmental Management, Inc. (E^{2}M) conducted an air monitoring program to evaluate the extent of releases of respirable dust (PM$_{10}$) from the former potliner storage area and the former disposal ponds. Wind speed and direction data for the period from May 1986 through April 1987, recorded at a meteorological station at the Ormet plant, were used to locate four air sampling stations at the site. The meteorological station at the Ormet plant records wind speed and direction continuously and then averages the data over one minute intervals. Two air samplers, AM-1 and AM-2 were situated predominantly downwind from the suspected sources of airborne particulate matter (i.e., the former potliner storage area and the former disposal ponds). The other two air samplers (AM-3 and AM-4), were located predominantly upwind from these areas.

The general locations of the air sampling stations are shown on Figure 79, while the surveyed locations, as determined by a licensed surveyor, are plotted on Sheets 8, 11, 12 and 14 of Appendix A. The survey data for these locations are listed in Appendix B.

The air monitoring program was begun on March 5, 1988 and continued until December 29, 1988. The air samplers operated continuously for 24 hours every six days. A description of the methodology used in the air sampling program is included in Appendix O-1. Filter post-weights were determined by Hazen Research, Inc. of Golden, Colorado. Filter pre-weight and post-weight data from the air monitoring program are presented in Table 42.

GERAGHTY & MILLER. INC.

2.4   Surface Water and Sediment Investigation

During the RI, samples of surface water and bottom sediment were collected from the Ohio River adjacent to the Ormet property. As part of Phase I, samples of bottom sediment were collected at the six general locations shown in Figure 80. More precise plots of the sample collection points are shown on Sheets 5, 12, and 15 of Appendix A. A description of the river water and sediment sampling procedures are provided in Appendix C-6.

The six river sediment samples and one field replicate were analyzed for a list of parameters shown below.

PARAMETERS ANALYZED FOR ON

PHASE I OHIO RIVER SEDIMENT SAMPLES

pH	Silica
% Solids	Ammonia-nitrogen
Alkalinity	Total Organic Carbon
Chloride	Cyanide (total)
Fluoride	Cyanide (amenable to chlorination)
Sulfate	

Organic and inorganic parameters of the USEPA CLP program, excluding pesticides, PCBs, and 2,3,7,8 and dioxin.

The results of these analyses are presented in Tables 43 through 46. As specified in the Consent Order Statement of Work (SOW), the Phase I sediment samples were not analyzed for

GERAGHTY & MILLER. INC

pesticides and PCBs because they were not detected in the samples from the former spent potliner storage area or the former disposal ponds.

Based on the results of the Phase I sediment sampling program, additional sediment sampling was included in Phase II of the RI. The Phase II sediment sampling program was intended to address the following general objectives:

- provide a more representative background sample;

- confirm the results of the Phase I sediment sampling program with regard to PAH concentrations;

- further evaluate the lateral extent of PAH compounds in the bottom sediment near the 004 outfall; and

- evaluate the possible presence of PCBs in the bottom sediments adjacent to the Ormet site.

To address these objectives, samples of bottom sediment were collected from the 12 locations shown in Figure 81. The Phase II sediment samples were analyzed for the semi-volatile organic compounds and pesticides and PCBs of the USEPA CLP list. The results of these analyses are provided in Tables 47 and 48. Summaries of semi-volatile organic compounds detected in the river sediment samples during Phase I and Phase II are provided in Tables 49 and 50, respectively.

The Phase II river sediment samples were also submitted to Pittsburgh Testing Laboratory to be analyzed for total combustible carbon content. The purpose of these analyses was to determine the total organic carbon content of the river sediments, as this can effect the mobility of certain organic compounds in the sediments. The results of these analyses are provided in Table 51.

Figures 82 through 86 present the concentrations of selected parameters of interest in the river sediments with distance downstream along the Ormet property. The parameters considered are total cyanide, fluoride, and total PAHs. The total PAH value was obtained by adding the concentrations of the one or more PAH compounds detected in each sample. The PAHs considered in the total PAH determinations include the following:

Naphthalene	Pyrene
2-Methylnaphthalene	Benzo(a)anthracene
Acenaphthalene	Chrysene
Acenaphthene	Benzo(b)fluoranthene
Dibenzofuran	Benzo(k)fluoranthene
Fluorene	Benzo(a)pyrene
Phenathrene	Indeno(1,2,3cd)pyrene
Anthracene	Dibenz(a,h)anthracene
Fluoranthene	Benzo(g,h,i)perylene

Also during the Phase II RI, surface water samples were collected from the Ohio River at five locations adjacent to the Ormet site (see Figure 81). The surface water samples were analyzed for the list of parameters given below.

PARAMETERS ANALYZED FOR ON

OHIO RIVER SURFACE-WATER SAMPLES

pH (field and laboratory)	Chloride
Specific Conductance	Fluoride
(field and laboratory)	Sulfate
Total Dissolved Solids	Tin
Total Organic Carbon	Cyanide (total)
Alkalinity	Cyanide (amenable to chlorination)
Ammonia-nitrogen	
Silica	

Organic and inorganic parameters of the USEPA CLP program.

The results of these analyses are provided in Tables 52 through 56.

GERAGHTY & MILLER, INC.

2.5   Geological Investigations

Prior to the RI, hydrogeologic investigations had been performed at the Ormet site by Geraghty & Miller (Geraghty & Miller, 1984a and 1986), Fred Klaer and Associates, Inc. (Klaer, 1972 and 1973), and Dames & Moore (Dames & Moore, 1977 and 1978). As a result of these investigations, interpretations regarding the geology of the unconsolidated deposits beneath the Ormet site were well documented.

However, as part of the Phase I RI, boreholes were drilled to install additional ground-water monitoring wells requested by USEPA and OEPA at three locations:

1)   immediately west of Pond 3;

2)   along the western side of the construction material scrap dump at a point approximately 200 feet south of MW-12; and

3)   approximately 100 to 200 feet southwest of well TH-3.

At each of these locations, the saturated thickness of the aquifer was found to exceed 20 feet, so a two-well cluster was installed. These clusters were designated MW-42 S&D, MW-43 S&D, and MW-44 S&D, respectively (see Figure 2), with the shallow wells ranging from 41.6 to 67.5 feet deep and the deep wells ranging from 64.0 to 91.8 feet deep.

The general locations of these monitoring wells are shown in Figure 87. More precise plots of the well locations, as determined by a licensed surveyor, are shown on Sheets 12, 14 and 15 of Appendix A. The survey data, including plant coordinates and elevations, are listed in Appendix B.

Borings logs and well construction logs for the monitoring wells installed during the Phase I RI are provided in Appendix L and a description of the drilling and soil sampling procedures is given in Appendix C-7. Geologic logs and well construction diagrams for monitoring wells installed during previous investigations are provided in Appendices A and B of the Phase I RI Work Plan.

Geologic information obtained from the installation of the new monitoring wells was used to modify previously constructed hydrogeologic cross-sections for the site. These figures, along with a cross-section orientation map, are provided as Figures 88 through 100.

In addition to the installation of the ground-water monitoring wells, soil borings were drilled around the perimeter of each of the ponds to assess the physical characteristics of the soil beneath the ponds. As specified in the Consent Order SOW, a total of 20 pond perimeter soil borings were drilled. Ten borings were drilled around Pond 5, four around Pond 4, and two around each of Ponds 1, 2, and 3. The general locations of these borings are shown in Figure 101. The locations for the borings were selected to provide areal coverage of the pond dikes. The boring locations, as determined by a licensed surveyor, are plotted on Sheets 8, 11, 12, and 15 of Appendix A. The tabulated survey data, including plant coordinates and elevations,are contained in Appendix B. Boring logs for the pond perimeter soil borings are provided in Appendix M. The drilling and soil sampling procedures are as described in Appendix C-7.

With the approval of both USEPA and OEPA, the pond perimeter soil boring program was modified to include the collection of Shelby-tube samples from fine-grained deposits (i.e., silts and clays) encountered in the borings. The Shelby-tube samples were collected according to ASTM Method 1587-83 (ASTM, 1985) and were submitted to NUS Laboratories of Pittsburgh, PA for

vertical permeability and cation-exchange-capacity analyses. The results of this testing are shown in Table 57.

The pond perimeter boring program was also modified to include the installation of piezometers in selected borings to provide additional water-level measuring points in the immediate vicinity of the ponds. Piezometers were installed in ten of the twenty soil borings, with four being screened into the upper ten feet of the water-table aquifer and six into perched ground-water zones that were encountered while drilling. The borings that were equipped with piezometers are indicated on Figure 101. Construction logs for the piezometers are included in Appendix M.

The soil descriptions contained in the boring logs were used to construct hydrogeologic cross-sections and fence diagrams depicting the geology beneath the former disposal ponds. These are contained in Figures 102 through 106. In addition, data from the monitoring well borings and the pond perimeter borings were used, in conjunction with information from existing wells at the site, to construct an isopach map of the clay and silt layer that exists beneath portions of the Ormet property. This map is included as Figure 107.

2.6   Ground-Water Investigations

2.6.1   Routine Ground-Water Monitoring

During the Phase I RI ground-water sampling event (June 21 through July 6, 1988), samples were collected from all MW-series monitoring wells at the site (see Figure 87), except for MW-23s, MW-24s and MW-26s, which were essentially dry at the time of sampling. All of the MW-series monitoring wells were analyzed for the list of parameters given below:

WATER QUALITY PARAMETERS ANALYZED FOR ON
ALL GROUND-WATER MONITORING WELL SAMPLES
DURING THE PHASE I RI

pH (field and laboratory)	Manganese
Specific conductance	Iron (total)
(field and laboratory)	Zinc
Ammonia-nitrogen	Copper
Total Dissolved Solids	Nickel
Total Organic Carbon	Cobalt
Alkalinity	Chromium (total)
Chloride	Lead
Fluoride	Cadmium
Sulfate	Barium
Arsenic	Aluminum
Sodium	Silica (dissolved)
Potassium	Cyanide (total)
Calcium	Cyanide (Amenable to
Magnesium	Chlorination)
	Selenium

In addition to this list of parameters, monitoring wells MW-2, 5, 8, 11, 12, 13, 14, 15, 16, 17, 18, 19, 28, 29s, 20d, 30, 31, 32, 33s, 33d, 34s, 34d, 35, 36, 37, 39s, 39d, 40s, 40d, 42s, 42d, 43s, 43d, 44s, 44d were also analyzed for the following parameters:

ADDITIONAL WATER-QUALITY PARAMETERS ANALYZED FOR
ON SELECTED GROUND-WATER MONITORING WELLS
DURING THE PHASE I RI

Antimony	Thallium
Beryllium	Tin
Mercury	Vanadium
Silver	

Organic parameters of the U.S. EPA CLP List.

The results of the Phase I ground-water analyses are given in Tables 58 through 67.

During the Phase I ground-water sampling program, five field duplicate samples were collected, as well as 12 field blanks and 10 trip blanks. Two of the 12 field blanks were collected on days when no samples for organic analyses were collected. Therefore, only 10 of the field blanks (#3 through #12) were analyzed for organic compounds. The results of analyses performed on the field duplicates are included in Tables 58 through 67. Data from the analyses of the field blanks are provided in Tables 68 through 72. The results of the trip blanks analyses are given in Table 73. Summaries of volatile and semi-volatile organic compounds and metals detected in the ground-water samples are provided in Tables 74, 75, and 76, respectively. Water sampling logs from the Phase I ground-water sampling program are provided in Appendix O.

Based on the Phase I data, selected analytical parameters were used to construct equal concentration maps for the aquifer beneath the site. The selected parameters included pH, total cyanide, fluoride, and sodium. These isopleth (equal-concentration) maps are provided as Figures 108 through 111.

As part of the Phase II RI, thirteen of the MW-series monitoring wells were re-sampled (February 22 and 23, 1990) to confirm the results of the Phase I program. The wells that were sampled during Phase II were MW-2, 3, 14, 17, 18, 19, 23s, 23d, 31, 34s, 35, 37, and 42s. Samples from these wells were analyzed for the following parameters:

PARAMETERS ANALYZED ON GROUND-WATER MONITORING WELLS DURING THE PHASE II RI

pH (field and lab)	Sulfate
Specific Conductance (field and lab)	Fluoride
Total Organic Carbon	Cyanide (total)
Silica (dissolved)	Cyanide (amendable to
Iron	chlorination
Sodium	Total Dissolved Solids

The results of the Phase II ground-water analyses are given in Table 77. Because only selected wells were re-sampled during Phase II, plume isopleth maps were not constructed.

During the Phase II ground-water sampling program, two field duplicate samples were collected and two field blanks were prepared. The results of analyses of these samples are included in Table 77 and Water Sampling Logs for the Phase II ground-water sampling program are included in Appendix N.

The procedures and protocols followed for the collection of ground-water samples during the RI are described in Section 3.6.5 of the Phase I RI Work Plan. During both the Phase I and Phase II ground-water sampling events, samples designated for metals analyses were filtered through fiberglass prefilters prior to being preserved, as described in Section 3.6.5 of the Phase I RI Work Plan. Because the alluvial aquifer beneath the Ormet site is relatively permeable, colloids (e.g., silica-related) and

other very fine particles are believed to be actually moving with the ground water. Filtration of the water through the fiberglass prefilters, which were used during the RI, does not have the same potential to remove mobile constituents from the ground-water samples, as would 0.45 micron filters.

At the outset of both the Phase I and the Phase II ground-water sampling programs, water-level data were collected from all TH- and MW-series monitoring wells at the site, as well as from the pond perimeter piezometers and designated river pool measuring points. The surveyed locations of these features, as determined by a licensed surveyor, are plotted in Appendix A. The survey data for each measuring point, including elevations and plant coordinates, are listed in Appendix B. The water-level data from the Phase I and Phase II monitoring events are provided in Table 78 and were used to construct the water-table contour maps shown in Figures 112 and 113.

2.6.2 Low-Level Monitoring for Polynuclear Aromatic Hydrocarbon Compounds

In accordance with Task 5.C. of the Consent Order SOW, ground-water samples were collected from monitoring wells MW-2, MW-14, MW-19, MW-31, MW-35, and MW-37 and analyzed for selected PAH compounds in accordance with the, "Method Validation Plan for Low-Level PAH Analysis by GC/MS", which was developed by Ormet at the direction of USEPA and OEPA. The samples were analyzed for naphthalene, benzo(a) anthracene, chrysene, benzo(k) fluoranthene, and benzo(a) pyrene using a detection limit of 20 ng/L (parts per trillion), as referenced in the OEPA memorandum dated March 29, 1991. The results of these analyses are provided in Table 77A and are discussed in Section 4.2.

2.6.3 Ormet Ranney Well Sampling

Included in the Phase II ground-water sampling program was the collection of a sample and a duplicate from the Ormet Ranney well. This sample was analyzed for the same list of parameters as the Phase II ground-water samples. The results of these analyses are included in Table 77 and the water sampling log is included in Appendix N-3.

2.6.4 Consolidated Aluminum Corporation (CAC) Ranney Well Sampling

Periodic mapping of ground-water flow beneath the Ormet site, dating back to 1983, indicates that pumping of the Ormet Ranney well and old interceptor wells maintain a ground-water divide between the Ormet property and CAC (see Figures 112 and 113). Water-level data (see Table 78) indicate that the position of this divide is typically somewhere beyond the Ormet property boundary, beneath the eastern portion of the CAC property. By this condition, the resulting flow of ground water is from beneath CAC toward the Ormet Ranney well and old interceptor wells. Therefore, no hydraulic potential currently exists for the migration of ground water beneath Ormet toward the CAC Ranney well (i.e., no migration pathway for the movement of affected ground-water from beneath Ormet toward the CAC well is apparent), as long as the pumping of the Ormet Ranney well is not interrupted for an extended period of time. As discussed in Section 3.5.1, ground water at the Ormet Ranney well would require over 200 days (about 7 months) to move to the CAC Ranney well, if the Ormet Ranney well and interceptor wells were shut off. The locations of the Ormet Ranney Well and the CAC Ranney well are shown on Figure 1.

In response to a request from the Agencies, Ormet requested permission from CAC to collect two water samples, one month apart, from the CAC Ranney well during the Phase II RI, to characterize the ground-water quality at the CAC well. Permission to collect the sample was granted by CAC and the samples were collected on June 22, 1990 and July 20, 1990. During each of these sampling events, a replicate sample was collected and a field blank was prepared. The ground-water samples from the CAC Ranney well were analyzed for the organic and inorganic parameters of the USEPA CLP List and other general water-quality parameters The results of these analyses are presented in Tables 79 through 83 and the water sampling logs are included in Appendix N.

It should be noted that the samples for ground-water analyses were collected directly from the CAC Ranney well using a Teflon bailer, before the water passed through CAC's treatment system, which includes filtration and chlorination.

2.7 Characterization of the CAC Ranney Well Drinking Water Quality

At the time that the ground-water samples were collected from the CAC Ranney well (Section 2.6.3), a separate set of water samples was collected and analyzed to characterize the quality of the water from the well with regard to drinking water usage. During each of the two sampling events, a replicate sample was collected and a field blank was prepared. The drinking water samples from the CAC Ranney well were analyzed for the primary and secondary drinking water parameters and a list of other volatile organic compounds (Federal Register, July 8, 1987). The results of these analyses are provided in Tables 84 and 85. A summary of volatile organic compounds detected in the CAC samples is given in Table 86. It should be noted that the samples for drinking water analyses were collected after the water had passed through CAC's treatment system.

DRINKING WATER PARAMETERS ANALYZED

ON SAMPLES FROM THE CAC RANNEY WELL

Primary Drinking Water Parameters

	ArsenicEndrin
Barium	Lindane
Cadmium	Methoxychlor
Chromium	Toxaphene
Lead	2,4-D
Mercury	2,4,5-TP Silvex
Nitrate	Turbidity
Nitrite	Gross Alpha
Selenium	Radium 226 and 228
Silver	Total Trihalomethanes
Fluoride	Benzene
Trichloroethylene	para-Dichlorobenzene
Carbon Tetrachloride	1,1-Dichloroethylene
1,2-Dichloroethane	1,1,1-Trichloroethane
Vinyl Chloride	

Secondary Drinking Water Parameters

Chloride	Manganese
Color	Odor
Corrosivity	pH
Fluoride	Sulfate
Surfactants (MBAS)	Total Dissolved Solids
Iron	Zinc.

Other Organic Compounds

Bromobenzene	1,1-Dichloroethane
Bromodichloromethane	1,1-Dichloropropene
Bromoform	1,2-Dichloropropane
Bromomoethane	1,3-Dichloropropane
Chlorobenzene	1,3-Dichloropropene
Chlorodibromomethane	2,2-Dichloropropane
Chloroethane	Ethylbenzene
Chloroform	Styrene
Chloromethane	1,12-Trichloroethane
o-Chlorotoluene	1,1,1,2-Tetrachloroethane
p-Chlorotoluene	1,1,2,2-Tetrachloroethane
Dibromomethane	Tetrachloroethylene
m-Dichlorobenzene	1,2,3-Trichloropropane
o-Dichlorobenzene	Toluene
trans-1,2-Dichloroethylene	p-Xylene
cis-1,2-Dichloroethylene	o-Xylene
Dichlormethane	m-Xylene
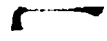
3.0   PHYSICAL CHARACTERISTICS OF THE STUDY AREA

3.1   Surface Features

The Ormet property is situated within the Ohio River Valley near the base of the West Virginia Northern Panhandle. This area is part of the Appalachian Plateau physiographic province and, in general, can be described as a highly dissected plateau or plain characterized by rugged topography, steep slopes, and strong relief, with elevations ranging from about 600 feet to more than 1400 feet above mean sea level. Stream erosion and transport, in conjunction with weathering and mass-wasting of slope materials, is largely responsible for the existing topographic expression of this region.

The Ohio River generally constitutes the feature of lowest elevation throughout the area and, thus, receives virtually all of the natural drainage via tributaries, surface runoff, overland flow, and ground-water discharge. Surface drainage patterns in the region can best be described as dendritic, where larger tributaries branch irregularly and angularly into smaller tributaries, resembling, in planview, the profile of a branching tree.

A notable exception to the rugged topography described above occurs in areas adjacent to the Ohio River and some of its major tributaries, where the deposition of flood plains and the carving of terraces into older and higher glaciofluvial outwash has created relatively level or gently inclined strips of land that tend to parallel the course of the river. These land features, which are commonly referred to as bottoms or bottomlands, are usually best formed on the inside of meanders (bends in a river) and fringe the Ohio River on alternate sides throughout its length. Owing to the relatively

flat-lying topography, the availability of water, and the close proximity to a major waterway, bottomlands along the Ohio River Valley have long been centers of population and industry.

As described in Section 1.3.1, the Ormet property is situated on the east-northeastern portion of an area of land known as Buck Hill Bottom on the west bank of the Ohio River. This lens-shaped stretch of land is approximately 2.5 miles long and up to 0.5 miles wide and is located on the inside of a meander (bend) in the river. The Ormet property occupies approximately 245 acres, with the process areas of the plant covering on the order of 110 acres in the southwestern portion of the property. The Ormet site is situated in the east-northeast portion of the Ormet property and is occupied by the former potliner storage area, the former disposal ponds, the former construction material scrap dump, the outfall 004 backwater area, and the carbon runoff area. The Ormet property extends farther to the northeast and includes undeveloped land, characterized by forestland and heavy underbrush, and a plant recreation area, which includes basketball and tennis courts, picnic facilities, and a baseball field.

Typically, the bottomland areas adjacent to the Ohio River are relatively flat-lying and may include floodplain and river-terrace features. In the Buck Hill Bottom area, two main terrace levels are present, with lower and upper terrace elevations averaging about 630 and 665 feet above mean sea level, respectively. The Ormet plant and much of the area of the property that comprises the Ormet site, which is the subject of the RI/FS, both lie on the upper terrace. The upper terrace is bounded on the northwest by a steep, heavily forested hillside that rises from Route 7 to an elevation of 1300 feet within less than a mile. The lower terrace is a relatively narrow strip of land (perhaps several tens of feet wide on average) that lies between the upper terrace and the Ohio River.

Several areas investigated during the RI are located entirely or partially on the lower terrace, which is in the 50 and 100-year flood plain, including the carbon runoff and deposition area, the construction material scrap dump, and disposal Pond 5.

3.2   Meteorology

Except for wind speed and direction (see Section 2.3, High-Volume Air Monitoring Study) site-specific meteorological data are not readily available for the Ormet site. However, data from Senecaville, Ohio (about 37 miles from Ormet) and from New Martinsville, West Virginia (about 4 miles from Ormet) are considered to be fairly representative of weather conditions in the study area. Climate data spanning the time frame between 1931 and 1965 are summarized in Table 87 (U.S. Department of Agriculture, et al., 1974). Total precipitation data recorded for 1989 at the Hannibal Lock and Dam, New Martinsville, WV are included as Table 88.

The climate in the vicinity of the study area is classified as temperate, with distinct seasons. Eastward passage of cyclonic storms create changes in weather patterns that result in considerable rainfall, snowfall, and humidity, with moderate cloud coverage and winds. Summers are moderately warm and humid, providing a favorable growing season for at least one harvest (Johnson, 1971). In an average summer, the temperature reaches 90°F or higher on about 15 days. Winters are generally cold and cloudy. An average winter has 5 days when the temperature is below zero (U.S. Department of Agriculture, et al., 1974, Johnson, 1971).

Precipitation varies widely, but is normally abundant and well distributed throughout the year, with Fall commonly being the driest season. Although precipitation is usually greatest in June or July and least in October, the average seasonal variation is small (Johnson, 1971). Showers and thunderstorms account for most of the rainfall during the growing season. Thunderstorms occur on about 45 days each year, usually between May and August. Along the Ohio River, near Hannibal, precipitation, including snowfall, averages about 39 inches annually (see Tables 87 and 88). Crop

yields are often reduced by droughts, but harvests are seldom completely lost. Snowfall generally occurs between the months of November and March in the Hannibal area. Snowfalls may be heavy (in excess of six inches of accumulation from a given storm), but are usually followed by thawing periods which generally leave no large accumulation for melting in the spring. The average annual snowfall is approximately 29 inches.

3.3   Surface Water Hydrology

The Ohio River forms the entire southern boundary of Ohio, extending from the junction of Pennsylvania, Ohio, and West Virginia, near East Liverpool in the northeast, forty miles below Pittsburgh. From there, the river follows an irregular course in a general south-southwesterly direction for 275 miles, to a point about twenty miles west of Cincinnati (491 miles downriver from Pittsburgh). The total drainage area of the Ohio River is 203,000 square miles (Van der Leeden et al, 1990) including 29,300 square miles, or 71 percent the total land area of the state of Ohio (U.S. Army Corps of Engineers, 1989). The river has been improved by construction of locks and dams to increase channel depths and to remove obstructions and assure adequate channel widths.

In 1975, the Army Corps of Engineers completed construction of the Hannibal Locks and Dam at Hannibal, Ohio, about three miles downriver from the Ormet site. Completion of the Hannibal Locks and Dam caused the pool elevation of the Ohio River adjacent to the Ormet site to increase by roughly 20 feet (USGS, 1960 and Karpacs, 1991).

In the vicinity of the Ormet property, the Ohio River pool elevation averages 623 feet above mean sea level, and as a result of the lock and dam structure, tends to remain fairly constant throughout high- and low-flow periods. Flood Information Studies (FIS) compiled from 1976-1977 data indicated that river flood stages along this reach of the river (in feet above MSL) would be about 630.5 feet during a 10-year flood event, 636.5 feet during a 50-year flood event, and 639.0 feet during a 100-year flood event (Army Corp of Engineers, 1977). The average discharge of the river at the Hannibal Locks and Dam is approximately 210,000 cubic feet per second (cfs).

3.4   Geology

The Ormet property is situated in the Appalachian Plateau physiographic province and is underlain by Paleozoic-age sedimentary rocks consisting mainly of conglomerates, sandstones, siltstones, shales, fresh-water and marine limestones, and coals, and lesser amounts of chert, iron ore, and rock salt or other evaporates (Price, 1956). In hilly, more elevated parts of the region, rock units are generally overlain by a thin to moderately thick layer of sedentary soil (also referred to as residual soil) that has been formed in place by the disintegration of underlying rocks and by the accumulation of organic material. These soils are usually relatively fertile and well drained and are capable of supporting woodland, cropland, and pasture.

In areas adjacent to the Ohio River, steep valley walls with outcropping rocks of Pennsylvanian- and Permian-age descend to the relatively flat-lying bottomland deposits characterized by floodplain and river-terrace features. River terraces beneath mid and upper portions of Buck Hill Bottom are thought to represent Pleistocene-age glacial outwash (i.e., sand and gravel) deposited as the glaciers retreated (melted) and that has been carved into a stepped profile by the downcutting Ohio River. Geologic cross-sections for the Ormet site are shown in Figures 89 through 100. The general locations of the cross-sections shown in these figures are depicted in the cross-section orientation map shown in Figure 88. The sand and gravel deposits beneath the Ormet site are fairly continuous down to bedrock, at a depth commonly ranging from 50 to 100 feet below land surface. Toward the valley wall, the sand and gravel deposits are commonly intermixed with and/or capped by colluvial material (clay, silt, rock fragments and other mudslide-type debris) derived from weathering and mass wasting of the highlands and the valley wall. Consequently, the relative abundance of fine-grained material increases beneath portions of the site that are nearer to the valley

wall (i.e., northern portions of the site). At varying depths within the alluvial sand and gravel deposits are thin (commonly less than about 1-inch thick) layers of what is interpreted to be decomposed coal (Geraghty & Miller, Inc., 1984), that was probably derived from the weathering of numerous coal outcroppings along the Ohio River. Since these thin layers have been recorded at depths throughout the sand and gravel aquifer, they are considered to be naturally occurring.

Beneath the areas of the site near the river, sand and gravel deposits are commonly overlain and/or interbedded with silt- and clay-rich deposits, that form a wedge that thickens toward the river. These near-river deposits are considered to represent floodplain deposits emplaced by the river during past regimes. Such deposits tend to contain predominantly silt and clay sediments, with lesser amounts of sand and organic (vegetative) material. An isopach map constructed for this layer of fine-grained material (Figure 107) indicates that it reaches a thickness of over 40 feet beneath portions of the site near the river. Analyses of Shelby-tube samples collected from the silt and clay layer at several locations beneath the Ormet site indicate that the vertical permeability of these deposits is commonly on the order of 10^{-7} to 10^{-8} cm/sec (see Table 57). Based on information from the RI and previous investigations conducted by Geraghty & Miller at the Ormet site (Geraghty & Miller, 1984), these low-permeability deposits appear to immediately underlie the carbon runoff area, the construction material scrap dump, and much of Pond 5, which should provide some degree of hydraulic separation between these surface features and the alluvial aquifer. Other areas of the site, including the former-potliner storage area, Ponds 1 and 2, Pond 3, Pond 4, and a portion of Pond 5, are underlain by predominantly sand and gravel. Fence diagrams and cross-sections depicting the geology beneath the former disposal ponds are shown in Figures 102 through 106.

3.5   Site Hydrogeology

Two types of water-bearing zones are present within the alluvial deposits beneath the Ormet site: 1) the Ohio River Valley alluvial aquifer, and 2) discontinuous zones of perched ground water.

3.5.1   Alluvial Aquifer

The Ohio River alluvial aquifer is composed primarily of the sand and gravel outwash deposits, and constitutes the main water-bearing unit in the area. This aquifer is currently utilized within the Buck Hill Bottom area, and is producing about four million gallons of water daily (mgd). Most of this volume is being pumped from two Ranney wells; one at the Ormet facility and the other at the CAC plant (see Figure 1). Approximately one mgd of the water, all pumped from the CAC Ranney well, is used as sanitary and potable water by Ormet and CAC employees. Approximately 2.5 mgd of water is pumped from the Ormet Ranney well for use in the Ormet reduction process, primarily as contact and non-contact cooling water. Approximately 0.34 mgd is currently pumped from the Ormet interceptor wells (#1 and/or #2), located about 200 feet to the north-northeast of the Ormet Ranney well.

Prior to June 1989, Ormet interceptor well #3 also pumped water from the alluvial aquifer, at a rate of about 175,000 gallons per day. However, the operation of this well was discontinued, with the concurrence of the USEPA and OEPA, when it was demonstrated that pumping of this well had no significant effect on the flow of ground water beneath the site or the containment of the plume that emanates from beneath the former potliner storage area. Additional discussions regarding the shutdown of interceptor well #3 have been included in Section 1.3.

GERAGHTY & MILLER. INC

When the #3 interceptor well was shutdown in June 1989, recovery data were collected from the interceptor well and used to calculate the transmissivity of the aquifer beneath this portion of the site. A resulting value of 74,608 gpd/ft was determined for the interceptor well and value of 110,710 gpd/ft was determined from recovery in the nearby MW-17 monitoring well.

Using the equation $K=(T/B)4.72 \times 10^{-5}$, where B is the saturated thickness of the aquifer (on the order of 40 feet near the #3 interceptor well) and 4.72×10^{-5} is a conversion factor for gpd/ft^2 to cm/sec, the hydraulic conductivities calculated for the alluvial aquifer using the #3 interceptor well transmissivity and the MW-17 transmissivity were 8.8×10^{-2} cm/sec and 1.3×10^{-1} cm/sec, respectively. The ground-water flow velocity was calculated using the equation $V=(KI/n) \times 1.03 \times 10^6$, where:

> V=ground-water flow velocity in feet per year;
>
> K=hydraulic conductivity of 8.8×10^{-3} cm/sec and 1.3×10^{-1} cm/sec;
>
> I=average hydraulic gradient beneath the plant area (about 0.0075 average from Figures 112 and 113);
>
> n=effective porosity, assumed to be 0.25 for a sand and gravel aquifer; and
>
> 1.03×10^6=conversion factor from cm/sec. to feet/year.

By this calculation, the ground-water flow velocities beneath the northeast part of the plant are calculated to range from 2719 feet per year (7.4 feet/day) to 4017 feet per year (11.0 feet/day). Taking the high end of this range, one can project that ground water is moving toward the Ormet Ranney well at a rate of about 4,000 feet per year (about 11 feet per day).

GERAGHTY & MILLER, INC.

Due to the increased relative abundance of fine-grained material (e.g., silt and clay) in the aquifer beneath the northern portion of the former potliner storage area, the transmissivity of the aquifer in this area is probably somewhat lower than that calculated for other areas of the site. Also, the saturated thickness of the aquifer decreases in this area and the average hydraulic gradient increases (see Figures 112 and 113). Consequently, the ground-water flow velocity beneath this part of the study area may vary from that estimated for other portions of the site.

Prior to the development of the aquifer (i.e., the installation of the Ranney Wells and subsequent pumping of ground water), the water table probably sloped from north to south, with ground water flowing toward and discharging to the Ohio River. Under current pumping conditions, ground-water flow in the alluvial aquifer beneath the Ormet site is generally from northeast to southwest, toward the Ormet Ranney well and interceptor wells. The operation of the Ranney wells has also caused the water table to drop below the level of the river. As a result, the primary source of recharge to the alluvial aquifer is water that is drawn from the river into the aquifer, with lesser contributions from infiltrating precipitation and from the adjacent and underlying bedrock system. As a result of the current pumpage, a hydraulic potential does not currently exist for the natural discharge of ground water from the alluvial aquifer to the Ohio River along the Ormet river/plant boundary. However, water discharging from the seeps at the base of the CMSD travels a short distance overland to the 004 outfall (see Section 4.3 for further discussion).

Ground-water withdrawals by the Ranney wells have created two large cones of influence, one around each pumping center, which converge to form a gently rounded ground-water divide that is situated roughly parallel and to the south of Ormet's southwest property boundary. A ground-water divide is hydraulically a high point, or ridge, in the surface of the water table. A ground-water

divide creates a hydraulic barrier, such that ground water on one side of the divide flows away from it in one direction, while ground water on the other side flows away in an opposite direction. In this case, ground water on the west/southwest side of the divide flows toward the CAC Ranney well, which is located about 2000 feet to the west of the Ormet Ranney well, while ground water on the east/northeast side (i.e., beneath the Ormet plant) is drawn toward the Ormet Ranney well. By this condition, a hydraulic potential does not currently exist for ground water beneath the Ormet plant to flow toward the CAC Ranney well. Assuming an average flow velocity of approximately 9 feet per day (as calculated earlier), ground water at the Ormet Ranney well would require over 200 days (about 7 months) to move to the CAC Ranney well, if the Ormet Ranney well and interceptor wells were shut off. Water-table contour maps constructed from water-level data collected during the RI are given in Figures 112 and 113.

The ground-water travel time calculated above is based on ground-water contour maps constructed with the Ormet Ranney well and interceptor wells pumping. If the Ormet Ranney well and interceptor wells were shut off, the hydraulic gradient beneath the Ormet site would be reduced and the ground-water flow velocity would decrease. Therefore, the calculated travel time of 200 days is a conservative (i.e., low-end) estimate of the time required for ground water to move from the Ormet Ranney well to the CAC Ranney well.

Water-level data from the monitoring well clusters at the site indicate that there is no clear trend in vertical hydraulic gradients in the alluvial aquifer. In general, the difference between water-level elevations in the shallow and deep wells of a well cluster is commonly on the order of a few hundredths of a foot. Exceptions have been observed at the MW-33 and MW-44 well clusters. At the MW-33 well cluster, water-levels recorded in the shallow well under the RI were more than one

foot higher than those in the deep well. Using the mid-point of the screened interval in each well of the MW-33 cluster as a reference point, these data indicate a downward gradient on the order of 0.07 ft/ft. By the same method of calculation, water-level data collected during the RI from the MW-44 well cluster also indicate a downward gradient, on the order of 0.03 ft/ft. These vertical gradient calculations are summarized in Table 78A. It is believed that ongoing pumping of the alluvial aquifer, possibly in conjunction with localized variations in the composition and relative permeabilities of the aquifer sediments, are responsible for the vertical gradients observed at these two locations.

The completion of the Hannibal Lock and Dam in 1975 caused roughly a 20-foot rise in river-pool elevation. Aside from an overall rise in ground-water levels of some 5 to 10 feet, the rise in the pool elevation of the river did not appear to cause any substantive change in the configuration of the water table under pumping conditions. Damming the river probably has caused some increase in silt accumulation along the river bottom adjacent to the Ormet site. Although silt accumulation may cause some reduction in the permeability of river-bed deposits (possibly reducing the hydraulic connection between the river and the water-table aquifer), the overall increase in the saturated aquifer thickness suggests that increased hydraulic heads (from the rising river) have more than compensated for such reductions.

3.5.2 Perched Ground-Water Zones

During the RI pond perimeter soil boring program, localized perched ground-water zones were encountered in several areas around two of the former disposal ponds (see Figure 101). One area of perched ground water was beneath the northeastern edge of Pond 5 (PPB-01, PPB-02, and PPB-10), another beneath the southwestern corner of Pond 5 (PPB-05 and PPB-07), and another near the

southwestern corner of Pond 4 (PPB-14). During the excavation of test pits in the former construction material scrap dump during Phase II, perched ground water was encountered at a depth of about 11 to 12 feet in Pit #2 , near the southwest corner of Pond 5. Based on the approximate elevation of the saturated zone encountered in Pit #2 compared to the elevation of the ground water in piezometers PPB-05 and PPB-07, the occurrences of ground water at these three locations are interpreted to represent the same saturated zone.

The results of the double-ring infiltrometer tests performed during the RI (see Table 15) indicate that the permeability of the pond surfaces can be categorized as low to moderate (US Dept. of Agriculture, 1951). The perched zones observed at several of the pond-perimeter borings are believed to be recharged by precipitation that infiltrates through the pond sludge materials and accumulates in layers of fill material beneath the pond dikes. These materials, which include coarse sand and gravel and brick (see Appendix M), are thought to be somewhat more permeable than the underlying sediments, which include finer sands or silt and clay. The extent of the perched zones appears to be limited both vertically and laterally. Water-level data from piezometers (see Table 78) that were installed into the perched zones indicate that the saturated thickness of these zones exhibits fluctuations ranging from less than 0.1 feet up to 6.1 feet between the two water-level measuring events.

Due to the proximity and similar elevations of the perched zones around Pond 5 to the seeps along the ballfield and the base of the construction material scrap dump and probably also the steel conduit, it is believed that these seeps and the water from the conduit represent, at least in part, discharge from the perched zones. At the time when the discharge from the steel conduit was sampled (July, 1988), the flow from the conduit was much less than one gallon per minute and the

collective discharge from the seeps was estimated at 5 to 10 gallons per minute. By this relationship, the water-quality data from the seep sampling and analysis programs that were conducted during the RI probably also reflect, to some degree, the water quality in the perched zones around Pond 5. These relationships will be discussed further in Section 4.2. The seeps are probably also recharged by precipitation that infiltrates through the overlying materials (e.g., the construction material scrap dump) down to the top of the silt and clay layer that underlies these areas of the site, and then flows laterally to the discharge point. Water that discharges from the seeps along the southwestern edge of the construction material scrap dump flows overland a short distance (less than 100 feet) to the 004 outfall stream. Water from the seeps that are located near the ballfield flows to a surface ditch that flows several hundred feet to the east-northeast to a small inlet of the Ohio River.

3.6 Demography and Land Use

3.6.1 Demography

The Ormet property is located approximately three miles north-northeast of the village of Hannibal in Monroe County, Ohio and the town of New Martinsville in Wetzel County, West Virginia. The population of Monroe County, according to the 1980 census, was 17,382 and the population of Ohio Township, where the plant is located, was 1,318. The village of Hannibal is a small community of fewer than 800 persons. New Martinsville, with a population of around 8,000, is the largest community in the immediate area (Clements, 1988).

Employment at the Ormet plant is about 1700, some of whom commute from other parts of eastern Ohio, West Virginia, and Pennsylvania. The total number of employed workers in Monroe County in 1986 was 4,858 (Clements, 1988).

3.6.2 Land Use

The region surrounding Hannibal, Ohio was once dependent on agriculture, and in 1986 a total of 790 farms still occupied 47% of the land area in Monroe County. However, the economy of the region is currently based predominantly on mining and industry, with 40% of the county's work force employed in manufacturing (Clements, 1988).

A map showing the general location of the Ormet property is shown in Figure 1. The Ormet property contains an active industrial plant occupying the northeastern portion of the area known as

GERAGHTY & MILLER, INC.

Buck Hill Bottom, a lens-shaped stretch of land approximately 2.5 miles long and up to 0.5 miles wide.

The Ormet property is bounded on the north by Ohio State Route 7 and on the east and southeast by the Ohio River. To the southwest of the Ormet property is Consolidated Aluminum Corporation, which is an active aluminum rolling mill. Areas to the north of the Ormet property are predominantly wooded and undeveloped. Additional discussions regarding the ecology of the study area are provided in Section 3.7.

3.7   Site Ecology

3.7.1   Soils

Within the hilly terrain of the unglaciated Allegheny Plateau are relatively infertile soils which support the most extensive woodlands in Ohio. The Ormet property is located on soils of the Huntington-Wheeling-Sciotoville association (U.S. Department of Agriculture, et al., 1974). In the study area, various soil types within this association are distributed in narrow bands oriented parallel with the Ohio River. The majority of Ormet plant structures lie on Made Land soils, which are excavated or graded soils generally composed of a mixture of miscellaneous soil material. Outward from the Made Land soils are soils of the Newark-Series (Newark silt loam) and Lindside-Series (Lindside silt loam). The Newark silt loam soil consists of deep, somewhat poorly drained loam. The Lindside silt loam consists of deep, medium-textured, moderately well drained soil. Both of these soil types typically form in water-deposited materials common in flood plain deposits. Soils of the Huntington-Series (Huntington silt loam) are found along the river's edge in the study area. These soils consist of dark-colored, well-drained soils that are deep and loamy.

Huntington Series (Huntington Silt Loam) soils typically support the following types of vegetation; red oak, white oak, black oak, tulip-poplar, white pine, black walnut, sugar maple, and white ash (U.S. Department of Agriculture et al., 1974).

3.7.2 Vegetation

At the time of the earliest land surveys, sections of the Ohio River Valley in southeastern Monroe County were part of the Mixed Mesophytic Forest region of Braun (1950). Uppermost slopes and ridge tops were occupied by oak-chestnut or oak-hickory communities, or, more often, by a combination in which oaks were dominant and chestnut and hickory equally abundant (Braun, 1950). In general, wooded areas along the Ohio River in Monroe County are today composed of plant species typical of an oak-hickory forest community. Local variations in climatic and soil conditions may alter plant community types.

A variety of vegetation grows on and in the immediate vicinity of the Ormet property. Deciduous tree species predominate and include maples, wild cherry, locust, dogwood, various types of oaks, sumac, hickory, beech, tulip tree, sweet buckeye, and basswood. Several small stands of pine trees are also present. On portions of the Ormet property, a variety of indigenous wild flowers and grass species exist. A small area adjacent to the 004 backwater area currently contains hydrophytic vegetation and saturated hydrology. However, the USEPA ecological survey (USEPA, 1991), which included an evaluation of the carbon runoff area and reference areas for the presence or absence of wetlands, did not identify any wetlands on the Ormet site.

Five plant species are listed by Hugo (1990) as either threatened or potentially threatened in Monroe County, Ohio. The State threatened plant species include Pipsissewa (Chimaphila umbellata), Rock Skullcap (Scutellaria saxatilis), and Sparse-Lobe Grape-Fern (Betrychium biternatum) and the potentially threatened species include the Tennessee Bladder Fern (Crstopteris tennesseensis) and Creeping Phlox (Phlox stolonifera) (Donohue and Associates, Inc., 1991). No threatened or

endangered plant species were identified on Ormet property by the USEPA field team (Donohue and

Associates, Inc., 1991). According to Donohue and Associates, Inc. (1991), no information concerning

aquatic plants or algae in the Ohio River near the site was located.

3.7.3 Mammals

A variety of mammal species commonly inhabit the wooded and grassy areas found along the

banks of the Ohio River, such as those found in the vicinity of the Ormet property, including

opossums, cottontail rabbits, skunks, chipmunks, woodchucks, squirrels, beavers, white-tailed deer,

field mice, and raccoons. During a site ecological survey conducted in November 1990 by USEPA's

Environmental Response Team, the following mammals were observed: deer mice, meadow vole,

groundhog, beaver, and white-tailed deer. Other common mammals found in Monroe County, which

may or may not inhabit the study area, are provided on Table 89. None of the mammals listed by

Donohue and Associates, Inc. (1991) or Table 89 are considered to be endangered or threatened

species (Huss, 1991).

3.7.4 Birds

The unglaciated counties in Ohio (including Monroe County) have traditionally received very

little attention in terms of the evaluation of bird distribution and abundance (Peterjohn, 1989).

Therefore, representative species lists are somewhat limited. The ecological environment of Sunfish

Creek State Forest, located on Ohio Route 7, approximately 12 miles north of the Ormet plant site is

considered to be similar to that of the study area due to its geographic proximity and similar

environmental setting. Several large and small bird species have been documented in the forested

hills and wooded overlooks along the Ohio River at the park (Thomson, 1983). A list of the bird species that have reportedly been observed in the Sunfish Creek area are presented in Table 90. It is Geraghty & Miller's interpretation that the wooded areas along the banks of the Ohio River adjacent to the Ormet property probably host many of the same bird species found in Sunfish Creek State Forest.

Some of the more common (or easily recognizable) birds that have been observed in the study area by Ormet and Geraghty & Miller personnel include; turkey vultures, Great Blue Herons, kill-deer, crows, gulls, mourning doves, robins, red-tailed hawks, wrens, sparrows, and woodpeckers. None of the birds included in Table 90 are known to be endangered or threatened species (Case, 1991).

3.7.5 Fish

The Ohio River hosts approximately 159 species of fishes. Fish species typically inhabit large sections of river environments. For this reason, fish distribution records for 1989 were divided into three reaches of the Ohio River according to river mile marker: upper (ORM 0-327 miles), middle (ORM 328-654 miles) and lower (ORM 655-981) (Pearson and Pearson, 1989). The Ormet property is located along the Ohio River at river mile marker 126. The fish species that inhabit the stretch of the river in the vicinity of the Ormet property are probably similar to those typically found in the upper reach of the river between river markers 0-327. A list of the fish species reported in the upper reach of the Ohio River in 1989 is presented in Table 91. Some of the more common types of fish include catfish, shad, bass and carp.

Hugo (1990) states that two State endangered and one special interest fish species have been identified in the vicinity of the site: the Ohio Lamprey (Ichthyomyzon bdellium) and Channel Darter (Percina copelandi) are both State endangered species and the Ghost Shiner (Notropsis buchanani) is a special interest species.

3.7.6 Macroinvertebrates

The macroinvertebrate community varies in species diversity and density along the site's shoreline (Donohue and Associates, Inc. 1991). The following macroinvertebrates were present at the site. Amphipods (Gammarus), mayfly larvae (caenidae), damselfy larvae (Chromagrion), midge larvae (Chironomidae), snails (Physa and Heliosoma), isopods (Asellus), annelids (Orgochaeta), and dragonfly larvae (Argia and Helisoma) (EPA, 1991). Because macroinvertebrates observed at the Ormet site were identified based on family designations, a determination as to whether threatened or endangered species are present is not possible.

3.7.7 Amphibians and Reptiles

No amphibians or reptiles were observed along the river shore of the site during the field survey described by Donohue and Associations, Inc. (1991). Geraghty & Miller personnel have observed box and snapping turtles at the site. Common amphibians and reptiles that may be present in the vicinity of the site include mud turtles, salamanders, frogs, toads, water snakes and black snakes. Because amphibians and reptiles observed or potentially present at the Ormet site were identified using common, general terms, a determination as to whether threatened or endangered species are present is not possible.

GERAGHTY & MILLER, INC.

4.0   NATURE AND EXTENT OF CONTAMINATION

4.1   Potential Source Areas

USEPA and Ohio EPA identified five areas at the Ormet site as possible source areas for the release or threatened release of hazardous substances, pollutants, or contaminants to one or more of the media (i.e., air, ground-water, surface water, sediment, and soil) at or adjacent to the site. During the RI, investigative activities were conducted to evaluate the physical and chemical characteristics of each of the following potential source areas:

- former disposal ponds,

- former spent potliner storage area,

- carbon runoff and deposition area,

- the former construction material scrap dump, and

- fill area adjacent to the plant recreation area.

The RI also investigated other areas and media at the site (e.g., the backwater area, river sediments, seeps, ground water) that were potentially affected by these possible source areas. Each of the areas or media potentially affected by the sources at the Ormet site are discussed later in Section 4.

Samples collected during the RI were analyzed for a list of parameters including the organic and inorganic parameters of the USEPA Contract Laboratory Program (CLP) List and other selected non-CLP parameters (e.g., fluoride, sulfate, TOC, ammonia-nitrogen, amenable cyanide); see Table

94 for a listing of the CLP parameters. The tasks which were conducted in each of the study areas under the RI have been described in Section 2.0. The remainder of this section summarizes the results of these investigations.

The CLP analytical data reported for soil, sludge, and sediment samples are derived through a total or extractable type of analysis. USEPA CLP analyses are specifically designed for NPL sites and are required to characterize contamination in media at NPL sites. Analytical data obtained for organic compounds using USEPA CLP methods involve sonication procedures to break the soil sample down into soil particles, and solvent extraction and/or dissolution of the organic compounds from the sample. The USEPA CLP methods for analysis of soils for metals use a concentrated acid solution (pH <2) to dissolve the metal constituents from the sample matrix. Because perchloric and hydrofluoric acids are not used, sample matrix components, such as silicate minerals, may not be dissolved by the acid digestion procedure.

The USEPA CLP methods of soil analyses yield results that reflect both the natural dissolvable and/or extractable constituents of the sample matrix, as well as the contaminants that may be present in the sample. These analyses are not intended to simulate the effects of natural leaching.

During the RI, samples from the various media at the site were analyzed by Compuchem Laboratories of Research Triangle Park, NC for total cyanide using CLP analytical protocols. Samples were also analyzed by Kemron Environmental Services of Marietta, Ohio for cyanide amenable to chlorination, which is a non-CLP analysis. The analysis for amenable cyanide first involves the analysis for total cyanide, which was also reported by the laboratory and is presented in the data tables of this report. Because different laboratories and methodologies were used for the CLP and

non-CLP cyanide analyses, direct comparisons of the resulting analytical data is not appropriate. For purposes of consistency, interpretations relating to total cyanide concentrations presented in this section are based on results from the CLP analyses, where available. Total cyanide reflects the combined concentrations of the relatively-stable cyanide complexes (e.g., iron cyanide, $Fe_x(CN)$), and free or simple cyanides, such as the CN-ion, and weak cyanide complexes, which are less stable and thereby "amenable" to chlorination. Consequently, concentrations of total cyanide are expected to be equal to or greater than corresponding concentrations of amenable cyanide. In general, the toxicity of cyanide complexes is related to the degree to which they dissociate to form free cyanide. Therefore, the relatively-stable cyanide complexes are considered to be less toxic than the less stable cyanide complexes, which are amenable to chlorination.

In evaluating analytical results for parameters that were also detected in associated laboratory blanks, the five- and ten-times rules were applied. By this procedure, no positive results were reported for common laboratory contaminants (i.e., acetone, methylene chloride, toluene, 2-butanone, and common phthalate esters) unless the concentration of the compound reported in the sample was at least ten times the amount detected in the associated laboratory blank. If the concentration reported in the sample was less than 10 times that of the blank, the sample concentration was qualified with a 'B'. If the reported concentration was less than 10 times that of the blank and was less than the CRDL, it was reported as [value] B. Similarly, no positive results were reported for uncommon laboratory contaminants unless the concentration reported in the samples was at least five times the concentration detected in the associated laboratory blank.

4.1.1   Former Disposal Ponds

At various times from 1958 to 1981, Ormet utilized one or more of the five retention ponds

(Ponds 1 through 5) located in the northeastern portion of the facility (see Figure 2). When in use,

Ponds 1 through 4 received predominantly sludge from the former pot-room wet scrubbing system,

but according to the best recollection of senior plant personnel, Ponds 1 through 4 may have also

received some minor amount of tailings material from the cryolite recovery plant after it began

operations in 1968. Pond 5 was put into service to receive tailings from the cryolite-recovery plant,

but may have initially also received minor amounts of sludge from the pot room wet scrubber system.

With regard to relative age, Ponds 1 and 2 are the oldest (operated between 1958 and 1978). Pond 5

was the last pond to be used (operated between about 1966 and October 1981). Ponds 3 and 4 were

operated between about 1960 and 1966.

The surfaces of Ponds 3, 4 and 5 have begun to support the growth of sparse vegetation. Pond

4 is currently covered with moss, and Pond 5 is sparsely vegetated with grasses, small trees, and

weeds. Pond 3 has begun to support the growth of grasses and small trees. Ponds 1 and 2 have little,

if any, vegetation growth. The particle-size ranges determined for surface solids in the ponds are

provided in Appendix P and summarized in Table 91A. With limited exceptions (i.e., samples 2B,

5A, 5C, and 5E), the surficial layer of the former disposal ponds is comprised predominantly of silt-

and/or fine sand-sized carbon material. Relative to the other ponds, the samples from Pond 4

contained somewhat greater percentages of clay-sized material.

Analyses of the composite sludge samples collected during the RI indicate that the materials

contained in the former disposal ponds are typically composed of from 45 to 70 percents solids by

GERAGHTY & MILLER, INC.

weight. (See Section 2.2.1 for a discussion of the collection of the composite samples). However, during the pond solids sampling program, distinct layers of relatively dry and compacted material, as well as zones of somewhat fluid material were observed. Overall, it appears that the moisture content of the pond sludges increases with depth.

Analytical data from the pond solids sampling program are provided in Tables 4 through 14. In the pond solids sampling program, background samples were not taken. The discussions concerning the pond solids analytical results are based on comparisons of the data for each pond or pond segment relative to the results for the other ponds and pond segments. In general, the disposal pond sludges are characterized by an alkaline pH (i.e., pH greater than 7.0) and the presence of cyanide, fluoride, chloride, sulfate, a variety of metals, and PAHs. Several of these parameters, specifically fluoride, chloride, sulfate, and alkalinity ($CaCO_3$) generally exhibit trends of increasing concentration with increased sampling depth in the ponds. Although in Ponds 3 and 4, the fluoride concentrations were highest in the sample from the 0- to 1-foot sampling interval and decreased with depth. Except for Pond 1 and Section B of Pond 4 (see Figure 3), where concentrations tend to decrease with depth, there is no obvious trend in the occurrence of the PAHs in the ponds. For the sake of convenience, the analytical data for semi-volatile compounds detected in the pond solids samples have been summarized in Table 14. Graphs depicting variations in the concentrations of selected parameters with depth in the disposal ponds are provided in Figures 8 through 47.

Only low concentrations (i.e., typically less than 0.1 mg/kg total and consistently less than 0.6 mg/kg total) of volatile organic compounds (VOCs) were detected in any of the pond solids samples. A summary of the VOCs that were detected in the pond solids samples is provided in Table 13. By the sporadic occurrence and low concentrations of VOCs observed, VOCs are not considered to be

primary indicator parameters associated with the pond materials. VOCs that were detected in at least two or more of the pond solids samples include chloroform (0.004 to 0.39 mg/kg), benzene (0.002 to 0.009 mg/kg), toluene (0.002 to 0.020 mg/kg), tetrachloroethane (0.002 to 0.047 mg/kg), carbon disulfide (0.002 to 0.079 mg/kg), and chlorobenzene (0.002 to 0.008 mg/kg). VOCs that were detected in only one pond sludge sample include 1,1,1-trichloroethane (0.004 mg/kg), styrene (0.002 mg/kg), and trichloroethene (0.002 mg/kg). Acetone (0.005 to 0.164 mg/kg) and methylene chloride (0.003 to 0.60 mg/kg) were also reported in several of the pond sludge samples. Acetone and methylene chloride were also commonly detected in associated laboratory blanks. A discussion of the 5 x and 10 x rule for considering laboratory blank values is provided in Section 4.1, page 3, paragraph 2.

Polychlorinated biphenyls (PCBs) were not detected in any of the disposal pond solids samples.

Data regarding the chemical make up of natural soils underlying the pond solids were not generated as part of the approved Phase I and II RI. With regard to impacts to ground-water beneath Pond 5, historical data show that following its decommissioning, ground-water quality showed substantial improvements (see Geraghty & Miller, 1984a, which is provided as an appendix to the Phase I RI Work Plan). Consequently, as long as the pond remains inactive and relatively undisturbed, no increases in the levels of contaminants in the ground-water in the vicinity of the pond would be expected.

Based on water-quality data from 8 of the 11 monitoring wells surrounding and directly downgradient from the former disposal ponds, the ponds appear to have much less significant impact on ground-water quality than the former spent potliner storage area (see Figures 108-111). PAH concentrations were consistently below the CLP CRDL. PAHs detected in ground-water samples

using a special analytical procedure (developed by Ormet at the direction of USEPA and OEPA) with

a 20 ng/L (parts per trillion) reporting limit are summarized in Table 77A. These data are discussed

in Section 4.2.

At the 8 well locations, CLP total cyanide concentrations range from 0.012 mg/L to 0.135

mg/L and fluoride concentrations range from 0.7 mg/L to 7.3 mg/L. These compare to background

fluoride of 0.5 to 0.7 mg/L, and background total cyanide (CLP) of <0.01 to 0.2 mg/L, as determined

from the MW-19 monitoring well. Analytical data from the remaining three wells around the former

disposal ponds (MW-17, MW-39s, and MW-42) reflect water-quality alterations related to

sources/conditions other than the former disposal ponds. A review of historical aerial photograph

indicates that the MW-39s well was installed in an area where spent potliner was handled and the

MW-42 well cluster is directly downgradient of this area and would be expected to show similar

effects. MW-17 is situated adjacent to the interceptor well and was affected by pumping of the

interceptor, which is no longer operating. At the time of the Phase I sampling (late June and early

July, 1988) the weather was hot and dry. A further discussion of water-quality trends around the

disposal ponds and within the former spent potliner storage areas is presented in Section 4.2.

There is also no evidence of surface water runoff from any of the former disposal ponds, as

the dike around each pond is intact and prevents stormwater from flowing from the pond surfaces

to surrounding areas and media. One of the ponds, Pond 2, does exhibit some seasonal standing water.

However, the surface water that accumulates on Pond 2 does not threaten to overtop the dike.

Additional information regarding the physical and chemical characteristics of the individual

ponds is discussed in the following sections.

4.1.1.1   Ponds 1 and 2

Former disposal Ponds 1 and 2 are located immediately to the northeast of the main plant area, adjacent to the anode crushing operation (see Figure 2). Combined, these two ponds occupy around 2.5 acres and are surrounded and separated by earthern dikes. The western edge of Pond 1 was constructed in a manner to utilize the natural contour of the area as the western retainment wall and, therefore, does not provide run-on control for this area of the pond. Information from pond-perimeter soil borings PPB-17, PPB-18, PPB-19, and PPB-20 (see Appendix M) indicates that the dike surrounding Ponds 1 and 2 is composed predominantly of clay and silt, with minor proportions of sand and gravel (see Figure 102). Logs from these boreholes indicate that these ponds are underlain by sand and gravel.

Based on data from the pond solids sampling program, the depth of the sludge material in Pond 1 ranges from around 5 feet to around 8 feet and Pond 2 varies from about 4 to about 6 feet deep (see Figure 4). In both ponds, the depth increases from north to south, which probably reflects the slope of the original land surface. The total volume of sludge material contained in Ponds 1 and 2 is estimated to be on the order of 14,500 cubic yards.

Results of analyses of the composite sludge samples collected from Ponds 1 and 2 indicate that the material in these ponds is characterized by pH ranging from 9.0 to 9.6, which is somewhat higher than in the other ponds. Based on the recollection of senior plant employees, the higher pH observed for Ponds 1 and 2 may be related to a small amount of unneutralized cryolite plant tailings (characterized by high pH related to the caustic digestion process) that may have been placed on Ponds 1 and 2 when the cryolite plant first began operations.

The analytical data for Ponds 1 and 2 suggest that there are several other differences between the chemical composition of the sludges in Ponds 1 and 2 and that of the materials in the other ponds. The concentrations of fluoride ranged from 214 to 1050 mg/kg, with six of the seven values less than 562 mg/kg. Total cyanide concentrations by CLP analyses ranged from 46 to 137 mg/kg. By comparison to the other ponds, samples from Ponds 1 and 2 were generally higher in these parameters than in Ponds 3 and 4, but lower than in Pond 5. The levels of cyanide amenable to chlorination (analyzed by non-CLP methods as specified in the Phase I and Phase II RI Work Plans and defined in Section 4.1) in Ponds 1 and 2 (7.5 to 176 mg/kg) were also higher than in the other ponds, except for Section A of Pond 4. In addition, the 4-foot interface sample in Pond 1 was higher than samples from Pond 2, Pond 5, and the other intervals in Pond 1 with regard to several metals, including calcium (319,000 mg/kg) chromium (59 mg/kg), iron (9330 mg/kg), lead (122 mg/kg), nickel (488 mg/kg), and vanadium (564 mg/kg). These metals concentrations are similar to those detected in samples from Pond 3 and Pond 4. Sulfate concentrations detected in Ponds 1 and 2 (100 to 1396 mg/kg), were generally lower than those detected in the other ponds. Aluminum concentrations in Pond 1 and 2 ranged from 48,000 to 68,100 mg/kg.

With regard to PAHs, the concentrations detected in Ponds 1 and 2 are generally similar to those detected in Ponds 3 and 5, but lower than those reported for Pond 4. Total PAH levels ranged from 33.75 to 78.2 mg/kg in Pond 1 and from 39.1 to 306.9 mg/kg in Pond 2. In Pond 1, the PAH concentrations generally decrease with depth (see Table 14 and Figure 11). In Pond 2, the highest concentrations reported were typically in the sample from the 0- to 1-foot interval. The concentration reported for the samples from the lower intervals were similar to one another.

The double-ring infiltrometer tests that were conducted during the RI yielded infiltration rates of up to 0.160 inches per hour (mean of 0.044 in/hr) for the surface of Pond 1 and up to 1.37 in/hr (mean of 1.05 in/hr) for Pond 2 (see Table 15). These rates were calculated from the inner-ring portion of the tests, which is considered to be most indicative of the vertical infiltration rate. According to the US Department of Agriculture (1951), the infiltration rates obtained for the surfaces of Ponds 1 and 2 are categorized as slow and moderate, respectively.

4.1.1.2   Pond 3

Former disposal Pond 3 is located just to the east-northeast of Ponds 1 and 2 (see Figure 2). Pond 3 is surrounded by an earthen dike and occupies approximately one acre. Information from pond perimeter borings PPB-11, PPB-12, and PPB-13 and monitoring wells MW-29 and MW-42 indicate that the dike is composed mainly of silt and clay, with varying amounts of sand, gravel, and rock fragments (see Figure 103). Logs from these borings also indicate that much of Pond 3 is directly underlain by sand and gravel. However, during the installation of monitoring well MW-14 (installed by Geraghty & Miller in 1983), which is located near the southeast corner of Pond 3, approximately 20 feet of silt and clay were encountered, suggesting that these deposits extend beneath the southeastern portion of the pond.

Data from the pond solids sampling program indicate that the sludge in Pond 3 varies from around 11.5 to nearly 14 feet deep, with the sludge depth increasing toward the northwest corner. The greater sludge depth in this portion of the pond appears to be primarily due to a build up of material at the surface near where the sludge discharge pipe to the pond was located, rather than a

depression in the pond bottom. The volume of sludge contained in Pond 3 is estimated to be on the order of 13,500 cubic yards.

The pH values of samples collected from Pond 3 (7.3 to 8.2) were lower (i.e., less alkaline) than those for samples from Ponds 1, 2, and 5, but slightly higher than samples from Pond 4. According to senior plant employees, the slightly higher pH values that were observed for Pond 3 may be related to a small amount of cryolite plant tailings (characterized by high pH related to the caustic digestion process) which may have been placed on Pond 3 when the cryolite plant first began operation. Senior plant employees also recollect that cyrolite tailings placed on Pond 3 may have been neutralized using spent pickling liquor (HCl), resulting in pH values that are lower than those observed for Ponds 1 and 2.

Samples from Pond 3 were also generally lower in fluoride (65 to 100 mg/kg, with one result of 534 mg/kg) and ammonia-nitrogen (below detection) than samples from Ponds 1, 2, and 5; Pond 4 exhibited similar fluoride and ammonia-nitrogen levels to Pond 3. With the exception of 88 mg/kg CLP total cyanide, which was detected in the sample from the 2 - to 5-foot interval, samples from Pond 3 were lower in CLP total cyanide (<0.85 to 8.1 mg/kg) than the other ponds. With the exception of the sample from the 0- to 1-foot interval, in which cyanide amendable to chlorination was reported at 6.7 mg/kg, cyanide amenable to chlorination was below the detection limit of 2.0 mg/kg in the samples from Pond 3. The concentrations to total PAHs for Pond 3 (22.45 mg/kg to 124.34 mg/kg) were lower than those reported for Pond 4, but are generally in the same range as Ponds 1, 2, and 5.

Compared to the other former disposal ponds, samples collected from Pond 3 were higher in arsenic (50 to 123 mg/kg) and chromium (41 to 110 mg/kg). Except for Pond 4, which exhibited similar concentrations, samples from Pond 3 were also higher than the other ponds in several other metals, including calcium (205,000 to 350,000 mg/kg), iron (7150 to 13,600 mg/kg), lead (80 to 214 mg/kg), nickel (199 to 581 mg/kg), and vanadium (204 to 741 mg/kg). The metals concentrations observed in the Pond 3 samples could be related to spent pickling liquor that may have been used to neutralize a small volume of cryolite plant tailings that were reportedly placed on Pond 3. With the exception of calcium, the concentrations of each of these metals were higher in the deeper samples from Pond 3. Aluminum concentrations in Pond 3 ranged from 53,800 to 88,900 mg/kg.

The double-ring infiltrometer test that was conducted on Pond 3 resulted in infiltration rates that ranged from 0.754 in/hr to 1.95 in/hr (see Table 15). These results are based on the inner-ring portion of the test, which is considered to be representative of vertical infiltration rates. According to the US Department of Agriculture (1951), the infiltration rates obtained for the surface of Pond 3 are categorized as moderate.

4.1.1.3   Pond 4

Former disposal Pond 4 is a roughly triangular-shaped pond located immediately north of Pond 3 (see Figure 2). Pond 4 is surrounded by an earthen dike and occupies about one acre. Information from pond perimeter borings PPB-11, PPB-14, PPB-15, and PPB-16 (Appendix M) indicates that the dike is composed predominantly of silt and clay, with minor amounts of sand and/or gravel and traces of rock fragments (see Figure 104). Logs from these borings also indicate that much of Pond 4 is directly underlain by sand and gravel.

GERAGHTY & MILLER, INC.

Data from the pond solids sampling program indicate that the sludge in Pond 4 varies from less than 6 feet deep to around 11 feet deep, with the eastern corner being the deepest part of the pond. The volume of sludge contained in Pond 4 is estimated to be around 17,800 cubic yards.

During the pond solids sampling program, Pond 4 was divided into two sections according to the specifications in the Consent Order SOW, with the northwestern portion being designated as Section A and the southeastern portion designated as Section B. Composite samples were collected for various depths in each of the pond sections. The composite samples collected from Pond 4 exhibited the lowest pH (and the lowest alkalinity) of all of the former disposal ponds, with values ranging from 7.1 to 7.2. Samples from Pond 4 were also generally lower than those from the other ponds, except Pond 3, in fluoride (60 to 146 mg/kg) and ammonia-nitrogen (below detection). Total cyanide concentrations detected by CLP analyses in the samples from Pond 4 (1.8 to 87 mg/kg) were similar to those detected in Ponds 1, 2, and 3, but were generally lower than those detected in samples from Pond 5. However, the levels of cyanide amenable to chlorination detected in samples from Section A of Pond 4 were similar to those detected in Ponds 1 and 2 and were higher than those detected in Pond 3, Pond 5, and Section B of Pond 4.

Similar to Pond 3, samples from Pond 4 were generally higher in several metals than samples from Ponds 1, 2 and 5, including calcium (268,000 to 352,000 mg/kg), chromium (34 to 64 mg/kg), copper (53 to 126 mg/kg), iron (7190 to 10,000 mg/kg), lead (12 to 212 mg/kg), nickel (286 to 656 mg/kg), and vanadium (389 to 640 mg/kg). The samples from the 0- to 1-foot interval in Sections A and B of Pond 4 were also higher in barium (308 and 423 mg/kg, respectively) than samples from the other ponds or the other sampling intervals in Pond 4. The higher metals concentrations observed in the samples from Pond 4 could be related to spent pickling liquors which, reportedly, may have

been applied to Pond 4 to neutralize cryolite plant tailings that may have been placed on Pond 4 when the cryolite plant began operations. This could also account for the lower pH values observed for Pond 4. Aluminum concentrations is Pond 4 ranged from 48,700 to 76,800 mg/kg.

The samples from Pond 4 also had higher concentrations of PAHs than samples from the other ponds, with concentrations in Section B of Pond 4 higher than those in Section A. Total PAH concentrations in samples from Section B of Pond 4 ranged from 142.8 to 693.45 mg/kg. Total PAH concentrations in Section A ranged from 71.38 mg/kg to 207.51 mg/kg. With few exceptions, total PAH concentrations in samples from the other ponds were less than 100 mg/kg.

The double-ring infiltrometer tests that were conducted on Pond 4 during the RI yielded infiltration rates of up to 2.22 inches per hour (mean of 1.072 in/hr) for the surface of Section A and up to 1.44 in/hr (mean of 0.82 in/hr) for the surface of Section B. According to the U.S. Department of Agriculture (1951), the infiltration rates for the surface of Pond 4 can be categorized as moderate.

4.1.1.4   Pond 5

Former disposal Pond 5 is located just to the east of Ponds 3 and 4 and adjacent to the southeast edge of the former potliner storage area (see Figure 2). Pond 5 covers approximately 12 acres and varies from less than 10 feet deep near the former potliner storage area to more than 28 feet deep adjacent to the Ohio River (see Figure 7). The increase in pond depth toward the southeast probably reflects the slope of original land surface. The total volume of sludge material contained in Pond 5 is estimated to be on the order of 370,000 cubic yards.

Information from pond perimeter soil borings PPB-01 through PPB-10 (see Appendix M) indicates that the dike surrounding Pond 5 is composed of about 10 to 12 feet of predominantly clay and silt with rock fragments, overlying assorted fill material (e.g., bricks, cinders, slag, rubble, etc.). Pond 5 underwent at least one expansion since it was first put into use in 1968. Originally, the area occupied by Pond 5 was approximately that of sections B, C, and E of the Phase I sampling program (see Figure 3). Between 1972 and 1974, the pond was expanded to the northwest to include the area that corresponds to sampling sections A and D. Boring logs from the pond perimeter soil borings and from monitoring wells installed in the vicinity of Pond 5 indicate that about the southeastern one half of the pond in underlain by silt and clay and that the northwestern one half of the pond is underlain by sand and gravel (see Figure 107).

Because Pond 5 received the tailings from the cryolite recovery plant, whereas the other ponds received sludges mainly from an air emissions wet scrubbing system, the analytical results for the pond solids samples from Pond 5 exhibit several differences compared to those for samples from the other ponds (see Tables 4 through 14). In particular, Pond 5 is generally higher in total cyanide and aluminum than the other ponds. This is because Pond 5 received predominantly tailings from the cryolite plant, which processed spent potliner material, and the other ponds received little or no cryolite plant tailings. The concentrations of CLP total cyanide in the samples from Pond 5 ranged from 87 mg/kg to 294 mg/kg (one value of 9 mg/kg and another of 44 mg/kg were also reported), while levels in samples from the other ponds were typically less than 90 mg/kg (three values of over 100 mg/kg were reported). The samples from Pond 5 were also generally higher in aluminum (61,300 to 105,000 mg/kg) than those from the other ponds (typically 48,000 to 88,900 mg/kg). In addition, the concentrations of chloride detected in Pond 5 samples (average of 112.5 mg/kg) were higher than

in the other ponds (average of 22.8 mg/kg). Sodium concentrations may also be higher in Pond 5, although this trend is not as consistent.

Overall, the total PAH concentrations detected in Pond 5 (12.4 to 180.36 mg/kg) were similar to the levels detected in Ponds 1, 2 and 3, but lower than Pond 4.

Of the five sampling sections in Pond 5, samples from Section D were generally lower than those from the other sections in the concentrations of several parameters, including sulfate, chloride, alkalinity,and fluoride. The concentrations of sulfate in samples from Section D were about a factor of 10 lower than in the other sections of Pond 5.

The results of the double-ring infiltrometer tests that were conducted near the center of each of the sampling sections in Pond 5 indicate that the surface of the pond is characterized by a moderate to rapid infiltration rate (US Department of Agriculture, 1951). The infiltration velocities recorded for the inner-ring portion of the tests ranged from 1.077 in/hr to 7.52 in/hr. Average infiltrations rates for the five pond sections were from 1.501 in/hr to 4.46 in/hr. The highest and lowest average infiltration rates were recorded in Sections C and D. respectively.

4.1.2   Former Spent Potliner Storage Area

As described in Section 2.2.2, soil samples were collected from 2-foot depth intervals (e.g., 0 to 2 feet, 2 to 4 feet, etc.) down to a total depth of 10 feet at 24 locations within the former spent potliner storage area and from the area of the site adjacent to and to the west of the former storage area (see Figure 48).

Results of analyses of the soil samples (see Table 16) indicated that certain parameters considered to be associated with spent potliner material, including pH, cyanide, fluoride, and sodium (i.e., the indicator parameters) occur at greater relative concentrations mainly in the central and southeastern portions of the sampling grid, particularly at boring locations SB-006 through SB-011 (see Figures 49 through 73); i.e., concentrations are high relative to other areas of the sampling grid. With limited exceptions, the levels of the indicator parameters that were detected in these areas generally decrease with depth. The highest reported values were typically for samples from the 0- to 2-foot or 2- to 4-foot intervals and the lowest values reported were commonly for samples from the 6- to 8-foot and/or 8- to 10-foot intervals.

Although the concentrations of the indicator parameters (i.e., pH, cyanide, fluoride, and sodium) generally decrease with depth, these parameters were still detected at greater relative concentrations in samples from the lowermost sampling interval (i.e., 8 to 10 feet) at several locations. Because precipitation infiltrating through soils in the former spent potliner storage area is considered to be the predominant source of alterations to ground water in the alluvial aquifer, levels of the indicator parameters above the interpreted background concentrations (see Table 16) are expected throughout the entire thickness of the unsaturated zone (i.e., down to the water table at depths of from about 30 to 40 feet) beneath portions of this area of the site.

The interpreted background ranges were based on the results for selected samples included in Table 16. These sample were identified based on a combination of the following criteria:

- The location of the sampling site within the soil-boring grid relative to the known areas of spent potliner storage and handling (i.e., results from soils borings located on

the outskirts of the sampling grid were considered to potentially be more representative of background).

- The depth from which the sample were collected. Samples from depth intervals below about 4 feet were considered to be potentially more representative of background conditions that near-surface samples.

- The pH of the sample, where samples with pH values above 8.0 were considered to potentially exhibit some indication of effects related to spent potliner and were not considered in the determination of the background ranges.

- The concentrations of cyanide and ammonia-nitrogen reported in the samples. Samples exhibiting detectable levels of cyanide and ammonia-nitrogen were considered to reflect effects related to spent potliner and were not considered in the determination of the background ranges.

In addition to the indicator parameters (discussed above), the samples from soil borings SB-006, SB-008, SB-015, and SB-016 were also analyzed for the organic and inorganic parameters of the USEPA CLP List (see Table 17 through 20). Concentrations of several metals detected in samples from the SB-016 boring were greater than those detected in samples from borings SB-006, SB-008, and SB-105, including aluminum (9710 to 35100 mg/kg), arsenic (12 to 20 mg/kg), chromium (23 to 168 mg/kg), copper (184 to 791 mg/kg), lead (21 to 74 mg/kg) and nickel (28 to 146 mg/kg). Also detected in the SB-016 boring was silver, at 11 mg/kg in the 4- to 6-foot sample. Aluminum was detected at relatively high levels in the 0- to 2-foot sample at SB-006 (13,500 mg/kg), the 0- to 2-

foot sample at SB-015 (42,500 mg/kg), and the 0- to 2-foot sample (20,300 mg/kg) and the 2- to 4-foot sample (11,700 mg/kg) at SB-008. Elevated concentrations (>10 mg/kg) of arsenic were also detected in the samples from the 0- to 2-foot interval (10 mg/kg) and 2- to 4-foot interval (13 mg/kg) at SB-008 and in samples from the 0- to 2-foot (11 mg/kg), 2- to 4-foot (10 mg/kg), and 6- to 8-foot (25 mg/kg) intervals at SB-015. Levels of lead greater than 20 mg/kg were also detected in the samples from 0- to 2-foot at SB-008 (21 mg/kg) and SB-015 (23 mg/kg).

The semi-volatile organic compounds detected in the soil samples from borings SB-006, SB-008, SB-015, and SB-016 are summarized in Table 21. PAH compounds were detected at relatively high levels in samples from each of these borings, except from SB-006. The only PAH reported in the samples from SB-006 was benzo(b)fluoranthene at 0.056 mg/kg in the 0- to 2-foot samples. This value is below the CRDL and was flagged "J" as an estimated value. Relative to the other borings, the highest concentrations of PAHs were detected in samples from SB-016. Total PAH concentrations in samples from SB-016 were up to 7067 mg/kg (2 to 4 feet). The PAH concentrations at SB-016 were much lower below a depth of 6 feet, but were still detected at elevated levels (226.1 and 207.1 mg/kg). Similarly, at SB-015, total PAH concentrations were comparatively high in the samples from the upper 6 feet (67.91 to 250.59 mg/kg). At the SB-008 location, elevated levels of PAHs were detected mainly in the 0- to 2-foot and 2- to 4-foot samples (3872.4 mg/kg and 77.88 mg/kg, respectively). These total ranges include PAHs detected at concentrations below the CRDL. A listing of all reported PAH values, including those detected below the CRDL, is summarized in Tables 21.

Other semi-volatile compounds reported in one or more of the soil samples from the four selected borings include phenol (0.120 to 1.70 mg/kg), 4-methylphenol (0.210 to 3.40 mg/kg), 2,4-dinitrotoluene (0.340 mg/kg), 2,4-dimethylphenol (0.072 and 1.80 mg/kg), di-n-butylphthalate (0.043

to 0.63 mg/kg), and bis (2-ethylhexyl)phthalate (0.200 to 1.10 mg/kg). No pesticides or PCBs were detected in any of the soil samples and the only VOCs reported above the CLP detection limit were methylene chloride (0.015 to 0.020 mg/kg), acetone (0.029 to 0.150 mg/kg), and 2-butanone (0.030 to 0.095 mg/kg). Both acetone and 2-butanone were also detected in the associated laboratory blanks (see 5 x and 10 x rule described in the introduction to Section 4.1 (page 2, paragraph 3).

The data from the soil sampling and analysis program indicate that to varying degrees, the soils of the unsaturated zone contain soluble inorganic constituents, including cyanide, fluoride, and sodium. The interpretation is that these constituents have been transported vertically downward by infiltrating precipitation. PAH compounds, which are relatively insoluble, were generally more concentrated in the samples from approximately the upper 6 feet of soil material.

The limited mobility of the PAH compounds is attributed to their relative insolubility and to their tendency to be adsorbed to natural organic material in the soils. Consequently, PAH compounds are not considered to be indicator parameters for the plume in the alluvial aquifer. PAHs detected in ground-water samples using a special analytical procedure (developed by Ormet at the direction of USEPA and OEPA) with a 20 ng/L reporting limit are summarized in Table 77A and discussed in Section 4.2.

Based on water-quality data from monitoring wells located within and immediately downgradient of the former spent potliner storage area (e.g., MW-2, MW-18, MW-35, MW-37), the former spent potliner storage area is considered to be the predominant source of water-quality alterations in the alluvial aquifer. This interpretation is discussed further in Section 4.2.

Stormwater runoff occurs generally from north to south across the former spent potliner storage area, but does not exit from the area to the south, due to higher ground in that area (see topographic maps in Appendix A). Rather, surface water tends to accumulate against the northeastern berm of Pond 4 and also, from time to time, in the southeastern corner of the former spent potliner storage area, in the vicinity of monitoring wells MW-34 and MW-17. Consequently, surface water runoff is not a pathway for migration of constituents from the former spent potliner storage area.

4.1.3 Carbon Runoff and Deposition Area

Data from the grid sampling program described in Section 2.2.4 (see Figure 76) indicate that the carbon deposits in the area west of the construction material scrap dump and south of Ponds 1 and 2 cover approximately 3 acres and are up to about 5 feet deep (see Figure 77). The area is heavily vegetated, supporting a variety of indigenous plant species.

The volume of carbon material present in this area is estimated to be on the order of 5,700 cubic yards. Based on the descriptions of the soil samples collected at each grid point (Appendix J), the entire carbon runoff and deposition area is underlain by predominantly silt and/or clay deposits. Analyses of eleven Shelby-tube samples collected from this silt and clay layer at locations MW-14, MW-20, MW-24, MW-33, MW-43, PPB-05, PPB-06, PPB-07, PPB-08, PPB-09, and PPB-10 at the Ormet site indicate that these deposits are characterized by a vertical permeability that is commonly on the order of 10^{-7} to 10^{-8} cm/sec (see Table 57). Two of the Shelby-tube samples (PPb-07 and PPB-10) yielded permeability of 10^{-5} and 10^{-6} cm/sec. For purposes of comparison, the low permeabilities of 10^{-7} to 10^{-8} cm/sec are in the range for materials commonly required by regulatory Agencies for the construction (i.e., lining and/or capping) of landfills.

GERAGHTY & MILLER. INC.

The results of laboratory analyses of samples of the carbon material and underlying soil are provided in Tables 33 through 41. These analyses detected relatively low concentrations of several VOCs. The VOCs that were detected in samples from the carbon runoff area are summarized in Table 40 and include chloroform (0.007 to 0.013 mg/kg), 2-butanone (0.057 mg/kg), benzene (0.310 and 0.350 mg/kg), tetrachloroethene (0.002 to 0.011 mg/kg), toluene (0.002 to 0.034 mg/kg), chlorobenzene (0.006 to 0.180 mg/kg), ethyl benzene (0.001 and 0.004 mg/kg), and styrene (0.007 mg/kg). Methylene chloride was also detected in samples from the carbon runoff and deposition area, and was detected in the associated laboratory blanks (see 5 x and 10 x rule described in the introduction to Section 4.1, page 3, paragraph 2.

Semi-volatile organics that were detected in samples of the carbon material and underlying soil are summarized in Table 41 and include 4-methylphenol (0.055 mg/kg), 2,4-dimethylphenol (0.150 and 0.180 mg/kg), di-n-butylphthalate (0.045 to 0.085 mg/kg), butylbenzylphthalate (0.130 mg/kg), and PAH compounds. Concentrations of total PAHs were higher in the carbon samples than in the samples of underlying soil. Total PAH levels detected in the carbon samples ranged from 15.151 to 149.6 mg/kg. Concentrations in the soil samples were from below detection to 9.033 mg/kg. These data do not indicate that PAHs are migrating downward through the underlying soils.

Samples collected from the carbon runoff and deposition area during the Phase I RI were not analyzed for PCBs. Analysis of a single composite sample of carbon material collected by the USEPA Environmental Response Team during its ecological survey of the site detected PCBs at 56 mg/kg (dry weight).

GERAGHTY & MILLER, INC.

With regard to metals, the concentrations detected in the carbon samples were typically higher than those in the corresponding soil sample. Specifically, metals that were detected at higher levels in the carbon include aluminum (56,500 to 107,000 mg/kg), antimony (20 to 56 mg/kg), arsenic (26 to 83 mg/kg), beryllium (3.3 to 7.8 mg/kg), calcium (109,000 to 194,000 mg/kg), cobalt (1.8 to 15 mg/kg), lead (24 to 76 mg/kg), nickel (61 to 558 mg/kg), sodium (7,830 to 10,900 mg/kg), and vanadium (36 to 233 mg/kg). Of these metals, several were detected at the highest concentrations at the B1 and B2 sampling locations, including arsenic (64 and 83 mg/kg), calcium (165,000 and 194,000 mg/kg), lead (76 and 66 mg/kg), nickel (286 and 558 mg/kg), sodium (10,800 and 10,100 mg/kg), and vanadium (211 and 233 mg/kg).

Four metals were commonly detected at higher concentrations in the soil samples than in the overlying carbon material. These include barium (170 to 278 mg/kg), iron (34,800 to 49,800 mg/kg), manganese (510 to _140 mg/kg), and zinc (128 to 194 mg/kg).

Cyanide was detected in both the carbon and the soil samples. Concentrations of cyanide (by CLP analysis) in the carbon samples ranged from 13 to 254 mg/kg and from 1.0 to 25 mg/kg in the soils. With the exception of the carbon sample from the B1 location, where cyanide amenable to chlorination was detected at 53 mg/kg, cyanide amenable to chlorination was not detected in any of the carbon or underlying soil samples. Fluoride concentrations in the soil samples (107 mg/kg to 238 mg/kg) were lower than in the carbon material (153 mg/kg to 298 mg/kg), with the exception of the C2 location, where the fluoride concentrations in the soil (355 mg/kg) was slightly higher than in the sample of overlying carbon (323 mg/kg).

As evidenced by the low concentrations of parameters such as PAHs, metals, and cyanide in the soils, relative to the levels of these parameters that were detected in the overlying carbon materials, vertical migration of constituents in the carbon deposits has been limited by the low permeability soils that underlie the area. Based on the information used to construct the isopach map for the silt and clay layer that is shown in Figure 107, the low permeability layer (10^{-7} to 10^{-8} cm/sec) ranges from about 10 to around 40 feet thick beneath the carbon runoff and deposition area. Based on the foregoing discussions, the carbon runoff and deposition area does not contribute to the plume in the alluvial aquifer.

The carbon runoff and deposition area is largely covered by grasses and trees. Two localized portions of the CRDA are devoid of vegetation and are subject to erosion and are within the 100-year flood plain. Although the area is relatively flat, surface runoff from this area drains toward the 004 outfall stream. During periods when the Ohio River is at major flood stages, areas of the carbon deposits could be inundated by water. However, being in a backwater area, swift currents would not be expected and erosion and transport of the carbon deposits is expected to be low.

4.1.4 Former Construction Material Scrap Dump

Based on discussions with long-term plant employees and a review of available aerial photographs, it appears that the area currently designated as the former construction material scrap dump (CMSD) received material from plant operations from about 1966 until mid-1979. Presented in Section 1.3.2.3 is a general list of the types of discarded materials from the Ormet plant that may have been disposed of in the former carbon materials scrap dump (CMSD). Many of the materials listed were directly observed during the reconnaissance survey of the CMSD and during the

excavation of test pits during the Phase II RI, and are visible in the photographs presented in Appendix H. Locations of the CMSD test pits are shown in Figure 75. These pits extended to a depth of about 15 feet and did not penetrate the base of the CMSD materials.

Based on information from the installation of monitoring well MW-13, which penetrates through the base of the CMSD materials, and visual observation of the exposed face of the CMSD, the depth of the CMSD materials may be on the order of 25 or more feet thick in some areas.

Laboratory analyses of the composite samples that were collected from the test pits detected a variety of organic and inorganic constituents, which is a result of the assorted nature of the materials present in the CMSD.

Several VOCs were detected at low concentrations (from below detection to 0.043 mg/kg) in the test pit samples (see Table 27), including carbon disulfide (0.004 mg/kg), 2-butanone (0.016 mg/kg and 0.043 mg/kg), 2-hexanone (0.002 mg/kg), toluene (0.002 mg/kg), ethylbenzene (0.002 mg/kg), and xylenes (0.002 mg/kg) (see Figure 75 for pit locations). The only semi-volatile organic compounds that were detected in the CMSD samples were PAHs. Analytical results for the PAHs detected in the CMSD samples are summarized in Table 32. Total PAH concentrations in the CMSD samples ranged from 297.06 mg/kg to 1981.5 mg/kg. Overall, the highest concentrations of PAHs were detected in the sample from Pit #3 (1981.5 mg/kg) Although, the results for the duplicate sample were lower (688.2 mg/kg) The lowest concentrations were detected in the sample from Pit #2 (297.06 mg/kg).

The only PCB detected in the CMSD solids samples was Aroclor 1248, at concentrations from 3.632 to 22.6 mg/kg. Analysis of the grab sample of the water that was encountered in Pit #2 detected also Aroclor 1248 at 0.725 mg/L. This sample, upon receipt by the laboratory, had separated into the water and oil phase and there was an insufficient volume of oil present to permit individual analyses of both phases. Consequently, the sample was emulsified (physically shaken) and analyzed as a composite.

With regard to metals, 18 of the 23 metals on the USEPA Target Analyte List were detected in the CMSD composite samples. Antimony, mercury, selenium, silver, and thallium were not detected in any of the samples. The detection of a variety of metals in the CMSD samples is probably due to the assorted nature of the materials deposited in the dump (see Section 1.3.2.3) and the acid-extraction type analysis that is run under the CLP program. These analyses do not simulate the effects of natural leaching.

Of the samples from the four CMSD test pits, the metals concentrations reported from the sample from CMSD #1 were generally higher than those reported for the other test pit samples. The metals that exhibited the highest concentrations in the CMSD #1 sample, relative to the other CMSD samples, included aluminum (121,000 mg/kg), barium (125 mg/kg), beryllium (3.80 mg/kg), cadmium (3.60 mg/kg), iron (26,900 mg/kg), lead (83.9 mg/kg), nickel (58.8 mg/kg), and vanadium (42.4 mg/kg). The reported concentrations of cobalt (11.4 mg/kg), magnesium (1670 mg/kg), manganese (1060 mg/kg), and potassium (1150 mg/kg) were highest in the CMSD #2 sample. Reported concentrations of arsenic (56.9 mg/kg), calcium (16,100 mg/kg), sodium (48,700 mg/kg), and zinc (125 mg/kg) were highest in the CMSD #4 sample. Copper was highest (542 mg/kg) in the CMSD #3 sample. It should be noted that the reported concentrations of several metals were highest in the

duplicate sample for CMSD #3, including barium (150 mg/kg), chromium (42.5 mg/kg), iron (27,800 mg/kg), lead (84.1 mg/kg), and nickel (62.5 mg/kg).

Total cyanide concentrations in the samples from the CMSD ranged from 7.90 to 21.7 mg/kg and amenable cyanide was below detection. Fluoride levels in the samples were from 440 to 540 mg/kg, probably reflecting the presence of cryolite bath material, which was commonly observed in the material excavated from the test pits.

Based on observations during the Phase II RI reconnaissance of the CMSD perimeter, surface water runoff is not considered to be an important pathway for migration of constituents from the CMSD. During the reconnaissance of the CMSD, no distinct features (e.g., ravines, runnels) were observed. Apparently, the very permeable nature of the CMSD materials results in a greater degree of infiltration than runoff. As discussed in Section 3.5, the seeps which emanate from the base of the CMSD (see Figure 74) are probably fed, at least in part, by precipitation which infiltrates through the relatively permeable materials in the CMSD. At the base of the CMSD, the water encounters the low- permeability silt and clay layer, which underlies the entire dump, and then flows laterally to the seep discharge points. During the Phase II RI, a reconnaissance of the CMSD perimeter was conducted with USEPA oversight and the only seeps that were observed were those along the southwestern toe of the CMSD. The analytical data for samples collected from the seeps at the base of the CMSD indicate that certain constituents, predominantly inorganic, are associated with the dump materials.

Analytical data for samples that were collected from the seeps during Phase I and Phase II are included in Tables 22 through 26. Water discharging from the seeps at the base of the CMSD is

characterized by concentrations of CLP total cyanide, fluoride, sulfate, silica, total organic carbon, alkalinity, dissolved solids, iron, and sodium.

The CLP total cyanide concentrations reported in the seep samples ranged from 0.163 mg/L to 0.950 mg/L; amenable cyanide was from below detection to 0.549 mg/L (detection limits for amenable cyanide were from 0.005 mg/L to 0.01 mg/L). The highest level of CLP total cyanide was reported in a sample from Seep #3 and amenable cyanide was highest in Seep #6. Fluoride and sulfate levels in the seep samples were from 62 mg/L to 160 mg/L and from 210 mg/L to 750 mg/L, respectively, and the concentrations of iron and sodium in the seep samples were from 0.408 mg/L to 1.720 mg/L and 1130 mg/L to 2270 mg/L, respectively. The highest concentrations of fluoride and iron were in Seep #5 and sulfate and sodium were highest in Seep #6.

In addition to iron and sodium, several other metals, including aluminum, chromium, manganese, and selenium were detected in one or more of the CMSD seeps. Aluminum was reported at 0.649 mg/L and 0.653 mg/L in Seep #2 , 0.839 mg/L in Seep #3, and 1.05 mg/L in Seep #5. These values are higher than those reported at Seeps #6 (0.407 mg/L). Manganese was detected in samples from Seep #2 (0.201 mg/L to 0.402 mg/L) and Seep #3 (0.155 mg/L to 0.176 mg/L), and chromium and selenium were detected in Seep #5 (0.060 mg/L and 0.0137 mg/L, respectively). These analyses were performed on filtered samples.

The analytical data for the CMSD seeps indicate only minor concentrations of volatile and semi-volatile organics. With the exception of acetone, which was reported at concentrations from 0.033 mg/L to 0.049 mg/L, the only VOCs that were reported above the CLP detection limit in samples from the seeps at the base of the CMSD were 1,1,1-trichloroethane at 0.005 mg/L and 0.015

mg/L in the sample from Seep #5 and Seep #6, respectively, and at 0.010 mg/L in the duplicate sample from Seep #2. Acetone was also detected in the associated laboratory blank (see 5 x and 10 x rule described in Section 4.1, page 3, paragraph 2). Only one semi-volatile organic compound was detected in seep samples at above the CLP detection limit. Bis (2-ethylhexyl) phthalate was reported in the duplicate sample from Seep #2 at a concentration of 0.016 mg/L.

Aroclor 1242 was detected in samples from Seep #2 and Seep #3. Reported concentrations ranged from 0.0036 mg/L to 0.0074 mg/L in Seep #2 and 0.00083 mg/L to 0.0023 mg/L in Seep #3. Aroclor 1242 was also detected in the backwater and the Ohio River surface water samples collected during the RI (see Section 4.3), but was not detected in sediment samples (see Section 4.4). These data indicate that the PCBs detected in the CMSD seeps have not impacted the sediments but potentially may contribute to backwater and surface water quality.

4.1.5 Plant Recreation Area Fill

Tasks were performed during the RI to investigate the nature and extent of an area of debris (construction rubble) located on the slope leading down to the Ormet baseball field (see Section 2.2.5). Soil borings that were drilled adjacent to the area of debris (RAB-1, RAB-2, and RAB-3) did not encounter rubble material, indicating that the occurrence of the debris is limited to the face of the slope.

Also, two seeps that discharge from the base of the slope leading down to the ballfield near the areas of debris (Seep #1 and Seep #4) were sampled and analyzed. The results of these analyses are included in Tables 22 through 26. Analytical data from the ballfield seep samples indicate that

they are characterized by the presence of cyanide, and elevated levels of several other inorganic constituents, including fluoride, sulfate, iron, and sodium. CLP Total cyanide concentrations detected in the seep samples ranged from 0.0794 to 0.733 mg/L, with the highest levels reported in Seep #1. However, amenable cyanide was highest in the sample from Seep #4, at 0.0686 mg/L. The results for Seep #4 also indicated relatively high manganese (31.3 mg/L). Fluoride, sulfate, and sodium concentrations were from 6.5 to 92 mg/L, 1000 to 5000 mg/L, and 945 to 3520 mg/L, respectively, with the highest levels of each of these being detected in samples from Seep #1. The samples collected from Seep #1 also had the highest pH (8.6) and aluminum was detected in the Phase II sample from Seep #1 at 1.03 mg/L.

The results of the analyses of the samples from the ballfield seeps do not indicate major impacts by organic constituents. The only organic compounds that were detected at concentrations above the CLP detection limit were detected in Seep #1 and include isophorone (0.036 mg/L), 1,2-dichloroethene (0.007 mg/L), chlorobenzene (0.066 mg/L), and toluene (0.005 mg/L). Chlorobenzene and acetone were also detected in the associated laboratory blanks (see 5 x and 10 x rule described in Section 4.1, page 3, paragraph 2).

4.2   Ground Water

Ground-water flow and water-quality data obtained during the RI indicate the presence of a plume in the alluvial aquifer that emanates mainly from the vicinity of the former spent potliner storage area. This plume is characterized by a basic pH, ranging from 8.0 to 10.5, and above-background concentrations of total cyanide, fluoride, and sodium. Background concentrations of these constituents, as determined from water-quality data from the MW-19 background well, are the following: pH, 7.3; total cyanide (CLP), <0.01 to 0.2 mg/L; fluoride, 0.5 to 0.7 mg/L; and sodium 21 to 32.2 mg/L. In the case of fluoride and sodium, Geraghty & Miller has found that typical background ranges for this part of Ohio are 0.1 to 1.0 mg/L and <20 to 50 mg/L, respectively. The above-background concentration trends for these indicator parameters are graphically illustrated by the plume isopleth maps presented in Figures 108, 109, 110, and 111, and are tabulated in Tables 66, 76, and 77.

From the area of origin, the plume moves with ground-water flow through a section of aquifer about 3000 feet in length toward the Ormet Ranney well and interceptor wells. By this flow condition, the plume body exhibits an elongate shape, with highest concentrations in the vicinity of the former spent potliner storage area (see Figures 108, 109, 110, and 111). As the plume is pulled through the aquifer toward the Ormet Ranney well and interceptor wells, concentrations decrease with distance from the source area. This trend is attributed mainly to mixing (dilution) and possibly attenuation within the alluvial aquifer system.

Results from the RI indicate that plume constituents are introduced to the ground-water system predominantly by precipitation infiltrating through the soils within the former spent potliner

storage area. Solids contained within and/or around one or more of the decommissioned retention ponds located immediately southeast of the former spent potliner storage area may have contributed to plume makeup, particularly during the active use of the ponds. The data generated during the Phase I and Phase II RI indicate that current pond-related contributions to the ground-water condition are much less significant than the affects caused by the former spent potliner storage area. The relationship of the former disposal ponds and former spent potliner storage area to the ground-water plume are shown on the plume isopleth maps for pH, total cyanide, fluoride, and sodium (i.e., the indicator parameters) on Figures 108 through 111. Certain of the monitoring wells were constructed using longer well screens (e.g., 30 to 40 feet) which could result in some degree of dilution in the ground-water samples.

Based on water-quality data from seven monitoring wells situated downgradient from the former disposal ponds (i.e., MW-14, MW-33 S&D, MW-34S&D, MW-39D, and MW-42D), the ponds have a much less significant impact on ground-water quality than the former spent potliner storage area (see Figures 108-111). At these seven well locations, the pH ranged from 6.8 to 8.1, sodium ranged from 29.4 to 68.6 mg/L, CLP total cyanide concentrations ranged from 0.012 mg/L to 0.135 mg/L, and fluoride concentrations range from 1.7 mg/L to 7.3 mg/L. These concentrations are in contrast to wells within and immediately downgradient of the former spent potliner storage area, which exhibit a pH up to 10.4, sodium up to 2640, and CLP total cyanide ranging from 1.47 mg/L to 18.2 mg/L, and fluoride ranging from 140 mg/L to 1000 mg/L (see Figures 108 through 111).

Analytical data from the other three wells (MW-17, MW-39S, and MW-42S) situated directly downgradient from the former disposal ponds reflect water-quality alterations related to sources/conditions other than the former disposal ponds. A review of historical aerial photographs

indicates that the MW-39s well was installed in an area where spent potliner was handled and the MW-42S cluster well is directly downgradient of this area and would be expected to show similar effects. The contaminants remnant of the former spent potliner evidently remain in higher concentrations in the upper part of the saturated zone. MW-17 situated adjacent to the interceptor well and was affected by pumping of the interceptor well, which is no longer operating.

The pH typical of the plume (i.e., greater than 8.0) is attributed to dissolution of basic salts (e.g., Na OH, Na_2CO_3, and possibly other bases) associated with the spent potliner material. The pH condition is thought to be at least partially responsible for the tea- to coffee-color appearance of the concentrated plume, by causing dissolution of natural organic material (e.g., humics and fulvics) within the aquifer matrix. This interpretation (discussed later in this section) is not from direct analysis of the samples, but draws from well-documented evidence that the humic and fulvic soil components are solubilized under an elevated pH condition. As an example, Black, et al (1964) describes a leaching procedure for the humic and fulvic soil fractions that uses a caustic solution.

Fluoride and sodium are regarded as main plume indicators, and are also parameters that occur as natural ground-water constituents. In the case of fluoride, detections were reported for all but three of the ground-water samples analyzed, including samples from monitoring wells located outside of the plume. In samples from wells outside the plume, fluoride concentrations typically ranged from 0.1 mg/L up to a few mg/L. In samples collected from wells intercepting the plume body, reported fluoride concentrations ranged from several mg/L up to 1000 mg/L. Fluoride concentration trends based on the RI data are shown on Figure 110.

Sodium was detected in all water samples, with concentrations around and away from the plume typically ranging from 20 to 50 mg/L. In samples from wells intercepting the plume body, sodium concentrations exceeded this range and were as high as 2640 mg/L (see Figure 111). Reported sodium concentrations in excess of 200 mg/L were consistently associated with samples having a pH of 9.0 or higher, and sodium values in excess of 1000 mg/L were consistently associated with a pH of 9.8 or higher. One interpretation of these data is that sodium-containing bases (e.g., NaOH, Na_2CO_3, and possibly others) are at least partially responsible for the above-neutral pH condition.

The fourth main plume indicator, total cyanide, reflects the combined concentrations of the relatively-stable cyanide complexes (e.g., iron cyanide $Fe_n CN$), and free or simple cyanides, such as CN^- and weak cyanide complexes, which are less stable and thereby "amenable" to chlorination. As shown on Figure 109, the relative-concentration trends for CLP total cyanide are generally similar to those for pH, fluoride, and sodium, with the higher concentrations in and around the former spent potliner storage area.

The makeup of ground water at the Ormet site was characterized through a program that included analyses for CLP organics and inorganics and other non-CLP analyses on water samples from over 50 monitoring wells around the site. Summary Tables 74 and 75, which indicate all reported detections of organic constituents from all analyses conducted on ground-water samples, are the basis of this interpretation. The detection limits for the various compounds are included in the full data listings presented in Table 58 through 63.

With regard to volatile organic compounds, tetrachloroethene (perchloroethylene or PCE) was reported at levels above the CLP detection limit in wells MW-2 (0.011 mg/L), MW-5 (0.012 mg/L),

MW-18 (0.022 mg/L), MW-30 (0.005 mg/L), and MW-31 (0.040 mg/L). The only other volatile organic compound reported at a level above the CLP detection limit was carbon disulfide in MW-37 (0.008 mg/L). Volatile organic compounds reported below the CRDL were chloroform in MW-34S (0.003 mg/L); 1,1-dichloroethane in MW-5 (0.001 mg/L) and MW-40S (0.002 mg/L); 1,1-dichloroethene in MW-44S (0.001 mg/L); 1,1,1-trichloroethane in MW-5, MW-30, and MW-40S at 0.002 mg/L; trichloroethene in MW-5 (0.002 mg/L) and in MW-2, MW-18, and MW-31 at 0.001 mg/L; benzene in MW-44S (0.002 mg/L) and MW-44D (0.001 mg/L); toluene in MW-42D (0.002 mg/L), MW-43D (0.004 mg/L) and in MW-28, MW-29D, and MW-44S at 0.001 mg/L; and carbon disulfide in MW-36 (0.001 mg/L) and MW-35/MW-48(dup.) (0.004 mg/L). All reported detections of volatile organic compounds are indicated on Table 74.

No PAHs were detected above the CLP CRDL in any of the ground-water samples analyzed. Phenanthrene was detected below the CLP CRDL, at 0.004 mg/L, in monitoring well MW-39s. In accordance with Task 5.C. of the SOW, ground-water samples from selected monitoring wells (MW-2, MW-14, MW-19, MW-31, MW-35, and MW-37) were analyzed for certain PAH compounds using a special analytical procedure (developed by Ormet at the direction of USEPA and OEPA) with a 20 ng/L (parts per trillion) reporting limit. The PAH compounds analyzed are the following: naphthalene, benzo(a) anthracene, chrysene, benzo(k) fluoranthene, and benzo(a) pyrene. Analytical results for the part per trillion analyses are provided in Table 77A. Chrysene and benzo(k) fluoranthene were reported in three of the samples (MW-2, MW-31, and MW-37) at concentration ranging from 28 ng/L to 95 ng/L and 25 ng/L to 44 ng/L, respectively. Benzo(a) anthracene and benzo(a) pyrene were reported in only one sample (MW-2 and its duplicate) at concentrations up to 32 ng/L and 35 ng/L, respectively. None of the selected PAH compounds were detected above 20 ng/L in the MW-19 background monitoring well or its field duplicate.

The measured concentrations for naphthalene are considered unusable because significant concentrations were reported in field and laboratory blanks. The other four PAH compounds were identified as being present in ground water, with measured concentrations being the amount found in sample extracts. Measured concentrations ranged between a reporting limit of 20 ng/L and 100 ng/L. The concentrations reported should be considered estimated, but the PAH's qualitative presence is accurate. Matrix spike recoveries for 100 ng/L PAH concentrations approximated 50-60%.

With regard to other semi-volatile organic compounds, the only compound reported at a level above the CLP detection limit was bis (2-ethylhexyl) phthalate in samples from wells MW-14 (0.021 mg/L) and MW-36 (0.170 mg/L). Bis (2-ethylhexyl) phthalate was also detected in the associated laboratory blank. Semi-volatile organic compounds reported below the CRDL were bis(2-ethylhexyl) phthalate in MW-2 (0.003 mg/L), and di-n-butylphthalate in MW-31, MW-34S(RE), MW-36(RE), and MW-40D at 0.002 mg/L and in MW-29D, MW-35(RE), and MW-40D(RE) at 0.003 mg/L. A summary of all reported detections of semi-volatile organic compounds is provided in Table 75.

Analyses of CLP parameters included pesticides and PCBs. None of these compounds were detected in any of the ground-water samples analyzed. Other analyses performed during the RI included CLP metals and non-CLP water-quality constituents including pH, specific conductance, total dissolved solids (TDS), total organic carbons (TOC), alkalinity, silica and major cations and anions.

Of the 50 or more ground-water samples submitted for analysis of CLP metals, silver was not detected in any of the samples, thallium only in MW-25 at 0.0028 mg/L, and cadmium in MW-2 and

MW-37 at 0.0049 mg/L and 0.012 mg/L, respectively. Antimony was reported in six ground-water samples at concentrations from 0.025 mg/L to 0.042 mg/L. Selenium was reported in five samples at concentrations from 0.0023 to 0.027 mg/L. Antimony and selenium were generally not detected in the same well, and the reported occurrences give no indication of any direct relationship to the plume. Five of the monitoring wells in which antimony was detected are located in the westernmost portion of the Ormet plant. Ground-water flow in this area is from northwest to southeast, from CAC property toward the Ormet Ranney well and interceptor wells. Selenium and antimony were not detected in the MW-19 background sample.

Mercury was reported above the detection limit in seven ground-water samples, with all but two of the reported values below or well below 0.001 mg/L. The two wells in which mercury was reported above 0.001 mg/L are MW-18 (0.0011 mg/L) and MW-37 (0.0016 mg/L). Mercury was not detected in the MW-19 background sample.

Lead was reported in a total of 29 ground-water samples. In monitoring wells MW-18 and MW-37, the reported lead values were 0.109 mg/L and 0.139 mg/L, respectively. Of the other samples in which lead was detected, the highest reported value was 0.019 mg/L, with the majority of detections at less than 0.010 mg/L. The concentration for lead reported in the MW-19 background sample was 0.006 mg/L.

Zinc and barium can be naturally occurring in ground water and were detected in nearly all of the water samples analyzed. In background well MW-19, zinc was reported 0.139 mg/L and barium was reported at 0.232 mg/L. To varying degrees, the zinc and barium concentrations may be somewhat higher in wells intercepting the more concentrated plume. However, with the exception

GERAGHTY & MILLER, INC.

of barium at MW-37 (4.8 mg/L), the concentrations of these parameters were consistently below 1.0 mg/L.

Manganese and iron are common in ground water of the Ohio River Valley and were detected in nearly all of the ground-water samples analyzed. Reported manganese values, which range from 0.01 mg/L to over 15 mg/L, do not appear to exhibit any consistent concentration relationships with the plume. Somewhat stronger concentration relationships are apparent between iron and the plume in the alluvial aquifer. In general, samples with the highest iron concentrations (up to 144 mg/L) were from wells within the more concentrated portions of the plume. These iron concentrations are thought to reflect the iron-cyanide complexes within the concentrated plume. In the MW-19 background sample, the concentrations of manganese and iron were 0.23 and 17.6 mg/L, respectively.

Other CLP metals that appear to show some relationship to the plume include arsenic (up to 0.394 mg/L), chromium (up to 0.401 mg/L), cobalt (up to 0.814 mg/L), copper (up to 1.02 mg/L), nickel (up to 0.767 mg/L), and vanadium (up to 0.369 mg/L). With the exception of nickel, all of these metals were detected in the MW-19 background sample at the following concentrations: arsenic 0.007 mg/L, chromium 0.008 mg/L, cobalt 0.008 mg/L, copper 0.019 mg/L, and vanadium 0.015 mg/L. Reported concentrations of these metals tend to be higher in the more affected monitoring wells (e.g., MW-2, MW-18, MW-31, MW-35, and MW-37). Beryllium values also show some relationship to the plume, although there were only four total detections of beryllium with the reported concentrations ranging from 0.002 to 0.035 mg/L. Beryllium was not detected in the MW-19 background sample.

Aluminum was detected in most of the ground-water samples at concentrations ranging from less than 0.100 mg/L to as high as 178 mg/L. In the MW-19 background sample, aluminum was reported at 8.30 mg/L. Aluminum values greater than 8.30 mg/L were reported in wells MW-18 (164 mg/L), MW-27 (9.9 mg/L), MW-31 (12 mg/L), MW-34S (11.5 mg/L), MW-35 (29 mg/L), MW-37 (178 mg/L), MW-38 (12.6 mg/L), and MW-39S (33 mg/L). Five of these wells intercept the identified plume. Aluminum concentrations, ranging from less than one to 8.30 mg/L, occurred both in wells exhibiting above-neutral pH and in wells exhibiting a normal, near-neutral pH.

Analyses for non-CLP constituents characterizing general water quality indicate several alterations associated with the above-neutral pH condition. Introduction of an above-neutral pH plume to an aquifer system that naturally exhibits a near-neutral pH causes natural buffering mechanisms to engage. These affects are thought to be evident in the concentration trends observed for dissolved silica and TOC, which show generally increasing concentrations relative to increasing pH. The interpretation is that weak natural acids (silicic and humic/fulvic) dissociate in response to the above-neutral pH condition, liberating hydrogen ions to buffer the caustic condition. As a result, ionized species of silica ($H_3SiO_4^-$) and TOC-contributors are produced. The sand and gravel deposits of the alluvial aquifer provide virtually unlimited silica, and thin layers of peat and/or weathered coal present within the aquifer matrix provide a source of natural organic material. The dissolution of natural organic material is thought to contribute to the tea- to coffee-color appearance of ground-water sampled from the high-pH plume (see previous discussion in Section 4.2).

GERAGHTY & MILLER, INC.

4.3   Surface Water

Data obtained during the RI indicate that CLP volatile and semi-volatile organic compounds, including PAHs, are generally below the CLP detection limits in the surface water. The only volatile organics reported were methylene chloride and acetone, which were reported in nearly all of the samples at values ranging from 0.001 to 0.002 mg/L and 0.008 to 0.020 mg/L, respectively. Both of these compounds were also detected in the associated laboratory blanks (see 5 x and 10 x rule described in Section 4.1, page 3, paragraph 2). Three semi-volatile organics, fluoranthene, pyrene, and chrysene were reported in the sample from SW-5, each below the CLP detection limit at an estimated concentration of 0.003 mg/L.

As described in Section 2.4, surface-water samples collected from the Ohio River at three locations upriver from the Ormet site were analyzed for selected PAHs using a special analytical procedure (developed by Ormet at the direction of USEPA and OEPA) with a detection limit of 20 ng/L. As shown in Table 56A, these analyses detected each of the PAH compounds that was being analyzed for, including naphthalene (29 ng/L to 140 ng/L), benzo(a) anthracene (48 ng/L to 3000 ng/L), chrysene (85 ng/L to 2900 ng/L), benzo (k) fluoranthene (38 ng/L to 1200 ng/L), and benzo (a) pyrene (at 3800 ng/L).

Of the CLP pesticides and PCBs analyzed, only Aroclor 1242 was reported in the SW-5 and SW-9 samples. The reported concentrations were 0.0015 and 0.0010 mg/L, respectively. The SW-5 and SW-9 sampling locales are within and immediately downstream from the backwater area, respectively. This backwater is situated adjacent to the southwest edge of the construction materials scrap dump. The interpretation is that Aroclor 1242 detected at SW-5 and SW-9 does not represent

the concentration dissolved in the river water, but is related to an oily film observed with the Seep

#2 water samples at the southwest toe of the construction material scrap dump, where Aroclor 1242

was also detected. Further discussion of these analytical results is provided in report Section 4.1.4,

which summarizes the data obtained from the seep-sampling program.

Analysis of surface-water samples collected within and downstream of the backwater area (i.e.,

SW-5, SW-9, and the more downstream SW-12 locale) indicate water-quality characteristics

attributable to certain on-site sources and to the contaminated ground water discharged through the

NPDES-permitted outfall 004. These effects are evident mainly by above-background pH and

concentrations of sodium, fluoride, and total cyanide. The highest values for pH (8.5), sodium (162

mg/L), and fluoride (12 mg/L) were reported for the SW-5 sample, which was taken from within the

backwater area of the outfall discharge. With distance downstream from the backwater area, these

parameters show a steady decrease to pH = 8.04, sodium = 52 mg/L, and fluoride = 3.3 mg/L at SW-9.

At the SW-12 location, the concentrations of fluoride (0.3 mg/L) and sodium (12.3 mg/L), and the

pH (7.8) approach the background levels indicated in SW-1. These SW-1 background levels are

fluoride = 0.1 mg/L, sodium = 10.1 mg/L, and pH=7.7. The SW-9 and SW-12 sampling locations are

about 150 feet and 300 feet downstream from the mouth of the backwater. The pattern of reported

total cyanide concentrations is somewhat anamolous, in that, reported values are higher in the SW-9

sample (0.428 mg/L), immediately downstream of the backwater area, than in the SW-5 sample (0.125

mg/L) collected from within the backwater. In the SW-12 sample taken furthest downstream, total

cyanide was reported at 0.0076 mg/L.

Of the CLP metals analyzed, data from SW-5 and SW-9 show some slight-increases (relative

to background) for dissolved arsenic (0.010 mg/L in SW-5 only), total (unfiltered) chromium (0.012

mg/L and 0.010 mg/L), total copper (0.026 mg/L and 0.016 mg/L), dissolved iron (0.812 mg/L and 0.357 mg/L), and dissolved manganese (0.726 mg/L and 0.349 mg/L). Actual background values for these parameters, based on the SW-1 sampling location, were as follows: dissolved arsenic (<0.004 mg/L), total chromium (0.004 mg/L and 0.006 mg/L), total copper (0.006 mg/L and 0.010 mg/L), dissolved iron (<0.042 mg/L), and dissolved manganese (0.175 mg/L and 0.177 mg/L).

As discussed in more detail in Section 3.5.1, the operation of the Ormet Ranney well maintains water levels in the alluvial aquifer that are below the river pool elevation. As a result, the primary source of recharge to the alluvial aquifer is water that is drawn from the river into the aquifer. Considering this hydraulic relationship, the potential exists for the Ohio River to contribute to the quality of water in the alluvial aquifer (see Section 4.2).

4.4   River Sediments

Analyses of river sediment samples reported four volatile organic compounds at levels above the CLP detection limit (see Table 43). These were methylene chloride, 2-butanone, acetone, and benzene. Methylene chloride was reported in a total of four samples including the upstream (background) sample RS-1 (0.049 mg/kg) and in downstream samples RS-2 (0.037 mg/kg), RS-5 (0.032 mg/kg), and RS-6 (0.038 mg/kg); acetone was reported at 0.032 mg/kg in the RS-5 sample and benzene was reported at 0.024 mg/kg in the RS-2 sample. 2-Butanone was reported in only one sample, RS-3, at 0.120 mg/kg. Acetone, methylene chloride, and benzene were also detected in the associated laboratory blanks (see 5 x and 10 x rule described in Section 4.1, page 3, paragraph 2).

Other than PAH compounds, there were eight semi-volatile organic compounds detected in the Phase I and Phase II river sediment samples. Of these eight compounds, only one was reported at a concentration above the CLP detection limit, dimethylphthalate at 0.52 mg/kg in the Phase I RS-6 sample. A summary of the reported concentrations of semi-volatile organic compounds detected in river sediment samples, including those detected at concentrations below the CRDL is provided in summary Tables 49 and 50.

Of the 18 PAH compounds included in the CLP analyses, naphthalene, 2-methyl naphthalene, and acenaphthylene were not reported above the CLP detection limit in any of the samples (see summary Table 49 and 50). Of the remaining PAH compounds, the higher total concentrations were consistently reported for the RS-5 and the RSII-5 samples (see Tables 49 and 50), which were collected from within the outfall 004 backwater area (see Figures 82 and 83). In the RI Phase I data set, PAHs for RS-5 and it's duplicate sample (RS-7) totalled 1457 mg/kg and 1635 mg/kg,

respectively, and in the RI Phase II data set, PAHs totalled 1122 mg/kg at RSII-5. These values were from six times to more than an order of magnitude higher than the total PAH concentrations reported for the RS-6/RSII-6 sediment samples, which were collected immediately downstream near the mouth of the backwater; i.e., RS-6 PAHs totalled about 60 mg/kg and RSII-6 and RSII-6 (duplicate) PAHs totalled about 26 mg/kg and 176 mg/kg, respectively. Further downstream, at the RSII-9 and the RSII-12 locations (see Figure 83), reported total PAH concentrations show a general decrease, ranging from about 7 to 32 mg/kg, with values typically in the 14 to 20 mg/kg range. Background total PAH concentrations, as determined from the RSII-1A, RSII-1B, RSII-1C, and RSII-1D sediment samples, ranged from 1.9 to 8.9 mg/kg.

Of the river sediment samples collected between the upstream (background) location and the backwater area, those from RS-4, situated several hundred feet upstream from the backwater, reported above-background concentrations of total PAHs in both the Phase I and Phase II data sets, at 22.4 mg/kg and 25.6 mg/kg, respectively. In samples collected upstream from RS-4, at the RS-2 and RS-3 locations, results of sediment analyses differ between the Phase I and Phase II data sets. In the Phase I data set (see Tables 49), total PAH values reported for RS-2 and RS-3 were 17.8 and 23.5 mg/kg, respectively, which are above the background range. In the Phase II data set, total PAH values reported for RSII-2 and RSII-3 were 10.0 mg/kg and 7.7 mg/kg, respectively, which are close to or within the background range.

Other parameters showing a relationship to the backwater area sediments include fluoride and sodium, and total cyanide. Fluoride concentrations at RS-5 and RS-6 were reported at 109 mg/kg and 27 mg/kg, respectively, as compared to background values ranging from 5.3 to 6.8 mg/kg. Total cyanide concentrations reported from CLP analyses of the RS-5 and RS-6 sediment samples were 42

mg/kg and 1.6 mg/kg, respectively, as compared to a background values of <0.63 mg/kg (see Figure 82 for fluoride and total cyanide concentrations). Sodium concentrations were elevated in the RS-5 sample only, at 2060 mg/kg.

Of the CLP pesticides and PCB analyses performed on sediment samples, only Aroclor 1248 was detected (on a dry weight basis). This parameter shows a relationship to the backwater area, with the highest reported concentration at RSII-5 (97.5 mg/kg) and substantially decreased concentrations in the sediment samples from downstream locations RSII-6 (2.2 mg/kg), RSII-9 (1.3 mg/kg in the sample and 1.1 mg/kg in the duplicate), and RSII-12 (2.5 mg/kg in the sample and 1.0 mg/kg in the duplicate). Aroclor 1248 was not detected in the RSII-1 background sediment samples (see Figure 83).

Analyses of river sediment samples collected during Phase I also included CLP metals. Of these, selenium, silver, and thallium were not detected in any of the samples. Antimony was detected at 9.4 mg/kg only in the background RS-1 duplicate sample and cadmium only in RS-2 (2.0 mg/kg) and RS-4 (1.7 mg/kg). Mercury was reported in three samples, RS-2 (0.39 mg/kg), RS-3 (0.22 mg/kg), and RS-4 (0.32 mg/kg).

A number of the CLP metals were detected in all or nearly all of the sediment samples. These include aluminum (6,580 mg/kg to 12,600 mg/kg), calcium (2,110 to 32,500 mg/kg), iron (12,500 to 47,700 mg/kg), manganese (519 to 1,490 mg/kg), zinc (106 to 524 mg/kg), barium (72 to 165 mg/kg), copper (28 to 119 mg/kg), chromium (13 to 52 mg/kg), nickel (10 to 73 mg/kg), lead (17 to 92 mg/kg), cobalt (2.7 to 32 mg/kg), vanadium (8.9 to 18 mg/kg), arsenic (5.3 to 12 mg/kg), and beryllium (0.94 to 2.0 mg/kg). With the possible exception of calcium, magnesium, and copper, none

of these metals exhibit concentration patterns indicating a relationship to the backwater area. The data give some indication that higher values reported for barium, chromium, cobalt, copper, iron, lead, manganese, mercury, zinc, and nickel may tend to occur in the RS-2, RS-3, and/or RS-4 samples, which are upriver from the backwater area. These metals concentrations may be related to rip rap material (mainly brick) that was emplaced along the river's edge of the CMSD during recontouring of the river bank in the late 1970s. The various metals that appear to show concentration trends (either increasing or decreasing) with distance along the river are plotted on Figures 84 through 86.

4.5 Air

The results of the high-volume air monitoring program that was conducted at the Ormet site in accordance with Section 2.8 of the Phase I RI work plan are discussed in the report entitled "Phase II of the Site Investigation Description, Section 2.8 Air Monitoring (SOW Task 3-H)" prepared by Energy & Environmental Management, Inc. (April, 1989). The program was designed to measure the amount of respirable dust being emitted from the suspected source areas. In accordance with Section 3.6.7 of the Phase I RI work plan, particulate matter less than 10 microns in aerometric diameter (PM_{10}) was considered "respirable dust" for purposes of the study.

A 10-month air monitoring program was undertaken utilizing sampling sites and sampling methods detailed in Section 2.8 of the Phase I RI work plan. Site selection was based on obtaining upwind and downwind samples to ascertain the amount of PM_{10} emissions due to wind erosion. Results from the 10-month program showed an average impact of 1.7 ug/m^3 resulting from wind erosion emissions from the suspected source areas. This result was developed from an upwind vs. downwind filter analysis at various wind speeds and directions which effectively subtracted out the air emissions from the existing plant allowable air emissions.

The report detailing the results was submitted to U.S. EPA and OEPA and is included as Appendix O-1 of this report. By way of transmittals dated October 26, 1989, and December 13, 1989, the April 1989 report was supplemented by additional information requested by the Agencies. These transmittals are provided in Appendices O-2 and O-3, respectively, of this report.

4.6   CAC Ranney Well

Sampling of the CAC Ranney (see Figure 1) well was conducted on June 22, 1990 and again on July 20, 1990. The samples for ground-water analyses were collected at the wellhead, before the water has passed any of the treatment steps applied by CAC. The samples for drinking water analyses were collected from a point in the main distribution line immediately after CAC's treatment system, which includes chlorination. The analytical results for the ground-water and drinking water samples are provided in Tables 79 through 86. Provided in the following sections are discussions of the results of the ground-water and drinking water data.

4.6.1 CAC Ranney Well (Ground Water)

Two VOCs were reported in the ground-water samples at concentrations above the CLP detection limit (see Table 79), methylene chloride and acetone. Methylene chloride was reported in both the June 22 sample and the July 20 sample and their field duplicates, at concentrations from 0.005 mg/L to 0.014 mg/L. Acetone was reported only in the June 22 sample and its field duplicate, at concentrations of 0.039 mg/L and 0.043 mg/L, respectively. Both of these compounds were also detected in the associated laboratory blanks and field blanks (see 5 x and 10 x rule described in Section 4.1, page 3, paragraph 2).

Four other VOCs were reported in the CAC Ranney well samples at concentrations at or below the CRDL, 1,1-dichloroethane (0.001 mg/L), chloroform (0.002 mg/L to 0.005 mg/L), 2-butanone (0.002 mg/L), and 1,1,1-trichloroethane (0.002 mg/L). For the June 22 sampling, both 2-butanone

and 1,1,1-trichloroethane were also detected in the associated laboratory blank (see 5 x and 10 x rule described in 4.1, page 3, paragraph 2).

No semi-volatile organic compounds, pesticides, or PCBs were detected in any of the CAC Ranney well ground-water samples (see Tables 80 and 81).

With regard to the main plume indicators for the Ormet site, the pH values for the CAC Ranney well samples were very consistent and near neutral (i.e., 7.2 to 7.3). Cyanide and cyanide amenable to chlorination were not detected in any of the samples. Fluoride concentrations (0.3 to 0.8 mg/L) and sodium concentrations (18.8 mg/L to 20.3 mg/L) were within the normal range for the alluvial aquifer. By these data, there is no indication of any alternations to the water quality at the CAC Ranney well related to conditions at the Ormet site. These data are also consistent the interpretation of ground-water flow in the alluvial aquifer (see Section 3.5.1 and Figures 112 and 113), which do not indicate a hydraulic potential, under current pumping conditions, for ground water beneath the Ormet plant to flow toward the CAC Ranney well.

In addition to sodium, four metals were detected in the CAC Ranney well ground-water samples at concentrations above the CRDL: calcium (61.0 mg/L to 64.3 mg/L), lead (0.015 mg/L), magnesium (9.60 mg/L to 9.89 mg/L), and manganese (1.18 mg/L to 1.35 mg/L). Four other metals were reported at concentrations below the CRDL: antimony (0.002 mg/L to 0.029 mg/L), barium (0.091 mg/L to 0.098 mg/L), potassium (2.12.mg/L to 2.48 mg/L), and zinc (0.004 mg/L and 0.006 mg/L). It should be noted that antimony was also reported in the associated laboratory blanks and field blanks (see 5 x and 10 x rule described in Section 4.1, page 3, paragraph 2). The remainder of

the metals reported in the CAC Ranney well samples were similar to or below the concentrations reporter in the samples from the MW-19 background well at the Ormet site.

4.6.2 CAC Ranney Well (Drinking Water)

Of the inorganic drinking water parameters analyzed on the samples from the CAC Ranney well (see Table 84), only manganese was detected at concentrations (1.3 to 1.4 mg/L) above an existing drinking water standard (manganese has a secondary drinking water standard of 0.05 mg/L).

Five VOCs were detected in the drinking water samples from the CAC Ranney well (see Table 86), including 1,1,1-trichloroethane (0.002 mg/L to 0.00253 mg/L), cis-1,2-dichloroethene (0.0207 mg/L to 0.0228 mg/L), chloroform (0.00082 mg/L and 0.00096 mg/L), dichloromethane (0.00514 mg/L), and 1,1-dichloroethane (0.0012 mg/L to 0.00145 mg/L). Chloroform was detected in the sample and field duplicate collected on June 22, but was not detected in the samples collected on July 20. Dichloromethane (also known as methylene chloride) was detected only in the June 22 sample and not in the field duplicate or the sample collected in July. Three VOCs, o-, m-, and p-dichlorobenzene, were detected in the field blank samples (concentrations from 0.0012 mg/L to 0.00497 mg/L) during both the June and July sampling events, but were not detected in the actual drinking water samples, indicating that these compounds are not associated with the CAC Ranney well.

By the data generated during the RI, there is no indication that the drinking water quality at the CAC Ranney is being affected by conditions at the Ormet site.

5.0   ANALYSIS OF CONSTITUENT FATE AND TRANSPORT

To evaluate fate and transport of a constituent, the chemical and physical properties of the constituent and the surrounding environment are evaluated. Factors that are considered include constituent mobility, persistence, and stability. Additional factors, such as the physical, chemical, and biological processes that may affect a constituent are also considered. The following is a brief list of factors or processes, physical or chemical characteristics, and environmental conditions that may influence the chemical fate and transport of an organic or inorganic constituent

Physical Factors:

(1)   Physical loss processes, such as volatilization, photolysis, and sorption.

(2)   Transport processes, such as dilution, advection, and dispersion.

(3)   Ground-water flow factors, such as characteristics of the porous media, hydrogeologic boundaries, and aquifer recharge capacity.

Chemical Factors:

(1)   Organic and inorganic content of the soils.

(2)   Ground-water temperature, electrical conductivity, cation and anion concentrations, and pH.

(3)   Chemical processes such as hydrolysis, acid-base reactions, redox reactions, and ion pairing or complexes.

Biological Factors:

(1)   Variety of species and strains of microorganisms in soils.

(2)   Aerobic and anaerobic microbiological processes.

Physical and chemical parameters that can affect the transport and fate of constituents detected at the Ormet site are listed in Table 92. The solubility of a compound in water is the maximum or saturated concentration of the compound in pure water at a specific temperature. Specific gravity is the ratio of the density of a compound to the density of water. If present at a concentration above its solubility (i.e., as separate phase), a compound with a specific gravity less than water, such as benzene, will float on top of the water surface, while a compound with a specific gravity greater than water, such as tetrachloroethene, will sink.

Vapor pressure is a property of a chemical in its pure state and is an important indication of the rate of volatilization. The Henry's Law Constant (H) relates the equilibrium vapor pressure of a compound to the aqueous concentration of the same compound; thus, determining the rate of volatilization of a compound from an aqueous environment. Benzene (H = 0.0056 atm-m^3/mol), for example, will volatilize from water faster than 2-butanone (H = 0.0000274 atm-m^3/mol).

The organic carbon partition coefficient (K_{oc}) is a measure of the tendency for organics to be sorbed by soil and sediment. For example, tetrachloroethene (K_{oc} = 364 ml/g) is sorbed four times more than benzene (K_{oc} = 83 ml/g). The parameters H and K_{oc} are not applicable to metals. The octanol-water partition coefficient (K_{ow}) is a measure of the distribution of a chemical at equilibrium between octanol and water and gives an indication of how the chemical will preferentially distribute into a solvent or water.

The bioconcentration factor (BCF) indicates the degree to which a constituent may accumulate in aquatic organisms (usually fish), coincident with ambient concentrations of the constituent in water. Specifically, BCF is a ratio of constituent concentration at equilibrium in organisms (wet

weight) to the mean concentration of constituent in water. Therefore, BCF is a measure of the tendency for a constituent present in water to accumulate in fish tissue.

The bioaccumulation factor (BAF) is a measure of a constituent's tendency to accumulate in aquatic organisms, as a result of ambient concentrations of the constituent in water and consumption of food containing the constituent. The BAF can be obtained from experimental studies by dividing the organism's total uptake rate from water and food by the elimination rate of the constituent. BAF values are not included in Table 92 because very few BAFs have been measured accurately and reported in the open literature, and their application to sites other than the specific location where they were developed is problematic and subject to uncertainty (USEPA, 1991b).

The half-life $(T_{1/2})$ is the time required for half of the original concentration to be degraded to nontoxic metabolites. Fate and transport properties of the organic constituents can be estimated based on the listed parameters.

5.1 Factors and Processes Affecting Constituent Fate

The fate and transport of different constituents varies based on degrees of persistence, physical and chemical properties, such as solubility or volatility, and whether the compound can be degraded naturally or only under induced conditions. The relative significance of each fate and transport mechanism for the constituents detected at the Ormet site is summarized in Table 93. The processes affecting constituent fate are discussed in the following sections.

5.1.1 Precipitation and Dissolution

Precipitation is the process a constituent undergoes when it transforms from a dissolved solute in solution phase to a separate liquid or solid phase. Precipitation occurs when the concentration of a constituent in aqueous solution exceeds its solubility limit Organic constituents usually form a separate liquid phase during precipitation, while inorganic constituents will normally transform into a solid precipitate.

Dissolution is the process in which a constituent undergoes a phase transformation from a solid or separate phase to an aqueous phase, because the concentration of the constituent in aqueous solution is below its solubility limit. The solubility limit of a constituent is defined as the maximum amount of a constituent that can be dissolved in a given amount of solvent (e.g., water) at a specified temperature and pressure. A solution that has reached its solubility limit is a saturated solution.

Precipitation and dissolution reactions are generally reversible, depending on the solubility of the constituents. Factors such as temperature, pH, K_{oc}, and K_{ow} will influence the solubility of

organic constituents. Organic constituents such as the heavier molecular weight PAHs (i.e., molecular weight greater than 178 grams/mole) are predicted to have low solubilities ranging from 2.06 x 10^{-1} mg/L (Fluoranthene) to 5.0 x 10^{-4} (Dibenz[a,h]anthracene). The reporting of only trace concentrations (low parts per trillion) of PAHs in ground water within areas where PAH concentrations were detected in soils is consistent with the low solubilities predicted for these compounds.

The solubility of inorganic constituents, such as heavy metals, is controlled by ionic species concentration, solution activity, temperature, and pH. Of these factors, pH is perhaps the most important, as most metals tend to exhibit increased solubility under low pH (acid) conditions. A further discussion of pH-related effects on metals solubility is provided in Section 5.1.5.

5.1.2 Volatilization

Volatilization of a constituent in an aqueous solution is a transformation from the aqueous to the gaseous phase. Chemicals with high vapor pressures and low solubilities may be susceptible to volatilization (USEPA, 1979). Volatilization is characterized by a first-order mass-action expression that considers the concentrations and diffusion at the liquid and gas phase boundaries. Organic constituents are considered volatile when they have Henry's Law Constants in the 10^{-2} to 10^{-3} atmospheres-cubic meter per mole (atm-m^3/mol) range; thus, volatilization occurs relatively easily for these constituents. With the exception of mercury and antimony, metals detected at Ormet site are not volatile. Cyanide, as hydrogen cyanide, and carbon disulfide are subject to volatilization from soil and water to the atmosphere.

5.1.3 Photolysis

Photolysis is the process whereby certain organic constituents break down to smaller constituents in the presence of light. This process is normally unimportant in ground-water systems, but it can be very important in surface soils and surface waters. The available information for the constituents detected at the Ormet site indicate that photolysis is of potential importance with regard to polycyclic aromatic hydrocarbons. As shown on Table 93, the potential role of photolysis in the breakdown of the 17 PAH compounds listed is predicted to be high. Because light is the energy that drives the photolysis process, PAHs that are shielded from light are less subject to photolysis. For PAHs that are strongly sorbed to soils and/or organic matter, it is expected that photolysis may be somewhat inhibited relative to a dissolved (non-sorbed) state, although no site-specific data are available to quantify this factor.

Photolysis is of relatively little importance with regard to breakdown of methylene chloride and PCBs; and unimportant for the remainder of the organic constituents in Table 80.

5.1.4 Hydrolysis

Hydrolysis is the reaction of water with other constituents. The information available for the constituents detected at the Ormet site indicate that tetrachloroethene, cyanide, bis(2-ethylhexyl)phthalate, and some of the metals, such as arsenic and chromium, may be subject to low degrees of hydrolysis. However, hydrolysis is not regarded to be a significant removal process for these constituents at the Ormet site.

5.1.5 Acid-Base Reactions

Acid-base reactions are considered special cases of hydrolysis. Acid-base reactions are influenced by the pH of the solution. The Bronsted-Lowry and Lewis concepts were used by Stumm and Morgan (1981) to define the acid-base reactions. According to the Bronsted-Lowry concept, an acid provides a proton and a base accepts a proton. Lewis bases are the same as Bronsted-Lowry bases. A Lewis acid, however, is more generalized than a Bronsted acid. In general, an acid is any substance which, when added to water, increases the hydrogen ion (H^+) concentration. Substances which, when added to water, increase the hydroxide ion (OH^-) concentration are called bases.

Acid-base reactions are controlled by the hydrogen ion activity. The hydrogen ion activity is measured by the pH, an important factor that affects the transport mechanisms of many organic and inorganic constituents. Solubility, sorption capacity, redox potential, and biodegradation capabilities are typically influenced by a pH change. The pH is particularly important in determining the fate and transport of many metals. Generally, acidic soils (pH <7) are more prone to leaching of heavy metals to ground water, whereas basic soils (pH >7) limit such leaching. The materials in the potential source areas at the Ormet site, including the former spent potliner storage area, the former disposal ponds, the CMSD and the carbon runoff area, typically exhibit pH values greater than 7.0. Under these conditions, the mobility of the heavy metals detected in the potential source areas at the Ormet site is expected to be limited.

Certain metals (i.e., aluminum) exhibit increased solubility under both low pH (acid) and high pH (basic) conditions. Under basic conditions, aluminum solubility can increase above a pH of 8 (Mason, 1952). This is consistent with the high pH and elevated concentrations of aluminum in

ground water beneath and downgradient from the FSPSA. As water with a basic pH returns to a more normal (neutral) pH condition, aluminum concentrations are subject to decrease by chemical precipitation in response to the reduced solubility at neutral pH. Arsenic is an example of a metal that is not considered to be insoluble or immobile at high pH values.

5.1.6 Redox Reactions

Redox (oxidation-reduction) reactions are defined as electron transfer reactions. Reducing agents (reductants) provide electrons and oxidizing agents (oxidants) accept electrons (Stumm and Morgan, 1981). Microorganisms catalyze nearly all important redox reactions that occur naturally in ground water (Freeze and Cherry, 1979). Based on the above definition, the valence state of atoms can change, resulting in an adjustment to the adsorption potential, ion exchange stoichiometry, solubility, toxicity, and other characteristics of a given constituent. The oxidizing (or reducing) capability is measured by redox potential (Eh). Therefore, Eh, as well as pH, can play an important role in predicting the transport mechanisms for some of the heavy metals in soil and ground water.

Redox reactions are particularly important to transport and fate in environmental settings where oxidation tends to liberate constituents that were relatively immobile under a non-oxidized state. A good example is in areas subject to coal mining, where exposure of coal and associated overburden rocks to oxidation can result in the generation of acid mine drainage. However, the types of waste materials present at the Ormet site are not particularly prone to oxidation or reduction under the redox conditions that are assumed to exist, and the overall role of redox reactions to transport and fate processes is expected to of limited significance.

Redox reactions are also important in the biodegradation processes of several constituents of concern at the Ormet site. For example, biologically-mediated dehalogenation of halogenated organics occurs only under low-Eh (reducing) conditions. This process will be discussed in more detail in Section 5.1.9, Biological Processes.

5.1.7 Sorption

Sorption is a term that designates processes that tend to remove constituents from the aqueous environment by binding the constituents in soil or sediment particles or separate liquid phases. Sorption may involve the accumulation of substances at a surface or interface; sorption in this case is also called adsorption. The adsorption process can occur at an interface between any two phases, such as liquid-liquid, gas-liquid, gas-solid, or liquid-solid interfaces. If charged ions are involved in the adsorption, where one ion type replaces another ion type on the soil surface, the process may be termed ion exchange. Adsorption is presumed to be a major removal mechanism of metal ions detected at the Ormet site. Sorption also includes the process called absorption, in which the molecules or atoms of one phase interpenetrate nearly uniformly among those of another phase to form a solution with the second phase. These interpenetrations occur in direct proportion to concentration.

The primary driving force controlling the sorption process is the affinity of the solute for either the solvent or the solid surface. The affinity of the solute for the solvent can be described in terms of solubility, and the affinity of the solute for the solid surface can be described in terms of attractive forces. There are three attractive forces that govern chemisorption: electrical; van der

Waals attractions, which govern physical adsorption; and chemical forces, in the forms of covalent, hydrogen, or other chemical bonds.

Soil materials that are important to sorption include organic colloids, clays, metal oxides and hydroxides, and limestone ($CaCO_3$). For some solutes though, solid affinity for the solute can play a subordinate role by comparison to the affinity of the aqueous solvent. Organic dipoles and large organic ions are preferentially accumulated and seek positions at the interface to a larger extent than easily hydrated ions (Stumm and Morgan, 1981).

Organic retardation, which refers to hydrophobic constituents sorbing onto organic material in the soil matrix, is estimated in the ground water by use of a retardation coefficient, which incorporates the octanol-water partition coefficient (Table 92). When the constituent concentration in the water is high and the quantity of constituent on the surface of the soil organic carbon is low, the net transfer is from the water to the soil. Since the transfer is an equilibrium process, it reverses when the concentration in the water is low and the quantity of constituent on the surface of the soil organic carbon is high.

5.1.8 Complexation and Ion Pairing

Inorganic constituents can exist in simple ionic form (i.e., free ionic form) or in uncharged or charged species in association with other ions. The association of charged or uncharged ions are called complexes or ion pairs. Complexes form because of the electrical attraction between ions of opposite charge. According to Johnson, et al (1988), in a complexation reaction, a metal ion combines with a species that functions as a so-called ligand. The metals and the ligand bind together to form

a new species called a complex. Important inorganic ligands include most of the common anions, and their strength depend highly on the metal ion with which they are complexing. Common inorganic ligands are OH^-, Cl^-, SO_4^{-2}, CO_3^{-2}, S^{-2}, NH_3, PO_4^{-3}, CN^-, H_2O, and polyphosphates.

Organic ligands generally form much stronger complexes than inorganic ligands (Johnson, 1988). Fulvic and humic acids are examples of organic ligands that can form complexes with metals in ground water, especially metals that act as strong Lewis acids (i.e., copper). In ground water with dissolved organic carbon at concentrations of less than 10 mg/L, complexing of metals ions with the dissolved organic matter is less significant. However, in ground water characterized by high dissolved organic carbon, such as occurs in the main plume body in the alluvial aquifer at the Ormet site, the movement of metals as organic complexes may be significant.

5.1.9 Biological Processes

Bioaccumulation, biodegradation, and biotransformation are biological processes that can cause changes in the chemical quality of ground water. Bioaccumulation is defined as a process by which living things retain constituents in cell tissues. For example, the rate or amount of bioaccumulation of lipid-soluble constituents that occurs is generally related to the body fat content and the lipid solubility of the constituent. Biodegradation is a term used to describe biological changes of organic constituents. Biotransformation is a term that describes biological changes of organic constituents into other organic or inorganic constituents. Biodegradation could result in biotransformation and bioaccumulation by enzyme-catalyzed breakdown of a constituent into simpler forms. Some redox changes, such as methylation, are examples of biotransformation.

Biological processes in aquatic and soil environments are carried out primarily by microorganisms. The effects of macrobiota are generally considered insignificant to the subsurface environment. The following processes are performed or mediated by the microorganisms in soil and water media:

(1)   Degradation of organic constituents;

(2)   Depletion of available oxygen supplies;

(3)   Participation in redox changes involving metals, such as arsenic, manganese, iron, chromium and zinc;

(4)   Production of CO_2 that subsequently forms carbonic acid (H_2CO_3);

(5)   Production of a variety of organic acids;

(6)   Production of large and/or small organic molecular species upon which other constituents can be sorbed and removed from the water phase;

(7)   Transformation of cyanide to mineral nitrogen compounds;

(8)   Conversion of ammonium to nitrate and conversion of nitrate to gaseous nitrogen compounds;

(9)   Methylation of metals such as mercury; and

(10)   Assimilation and removal of organic and inorganic constituents by incorporating these constituents in the biomass.

Chemical factors influencing the biodegradability of constituents are as follows:

1.   Chemical structure;

2.   Physical and chemical characteristics, such as solubility, volatility, hydrophobicity, octanol-water partition coefficient, etc.;

3.   The presence and concentration of other constituents;

4.   Organic matter content of the soil;

5.   Amount and type of clay minerals in the soil;

6.   Water and soil pH; and

7.   Water and soil oxygen levels.

8.   Availability of nutrients (i.e., nitrogen and phosphorous).

Microorganisms can couple the oxidation of organic constituents to the reduction of iron, sulfate, or manganese oxides (Lovley, 1987). They can also oxidize aromatic hydrocarbon compounds, such as benzene, to carbon dioxide and water. They also may cause high concentrations of iron in some ground waters. These microorganisms can be found in ground water to depths of more than 650 feet (Lovley, 1987).

Biological degradation is influenced by the chemical structure of an organic constituent. Chemical and physical characteristics (solubility, volatility, hydrophobicity, and octanol-water partition coefficient) of a constituent are determined by molecular composition and orientation of the constituent. The availability of a constituent in solution and its tendencies for microbial consumption can be evaluated by the chemical and physical characteristics of the constituent.

The spatial relationship between the substrate (organic constituent) and the microorganism's enzymes influences the susceptibility of a constituent to biological degradation. Enzymatic activity depends on the proper stearic fit between enzyme and substrate. Enzymes only attack substrates that are of specific shape and orientation. Halogenation, such as chlorination, is often known to be responsible for increased persistence of organic constituents. Biodegradability of halogenated constituents is influenced by their chemical characteristics, including the nature of the halide involved, the number of attached halogen atoms, and the location of the halogen atom or atoms on the hydrocarbon chain or aromatic ring.

Some of the organic constituents detected at the Ormet site are halogenated. Dehalogenation is usually the first step in the biodegradation of these constituents. Many constituents are degraded by anaerobic reductive dehalogenation. The redox potential (Eh) must be lowered to less than 0.35 volts before significant reductive dechlorination occurs (Esaac and Matsumura, 1980). Biodegradation of halogenated compounds can also be limited depending on the degree and positions of halogens on the compound.

Environmental factors, such as moisture content, temperature, and aeration, must be considered in evaluating biodegradation potential. The moisture content affects biodegradation due to an increase in the dissolution of constituents, as well as an increase in the dispersive action through the medium. Temperature is also a critical factor in determining biodegradation rates, as biotic and abiotic processes proceed more rapidly as the temperature increases. Microbial activity usually peaks at 45°C, but then declines and eventually ceases as temperature continues to increase. Some organic constituents are biodegradable under either or both aerobic or anaerobic conditions. Organic constituents with benzene rings readily degrade under aerobic conditions, and degrade more slowly under anaerobic conditions. Many one- and two-carbon aliphatic constituents require anaerobic conditions for maximum degradation. Chlorinated benzenes are metabolized only under anaerobic conditions.

Table 93 summarizes the relative importance of biodegradation for the constituents found at the Ormet site. Limited information exists to indicate the different rates at which biodegradation occurs in different physical systems. Biodegradation may explain the presence of some of the compounds detected in trace concentrations at the Ormet site (e.g., 1,2-dichloroethene could form from the degradation of tetrachloroethene and methylene chloride from chloroform).

5.2   Constituents

Fate and transport mechanisms will be discussed for each of the metals, carbon disulfide, cyanide, bis (2-ethylhexyl) phthalate, and PCBs. Polycyclic aromatic hydrocarbons, monocyclic aromatic hydrocarbons, and chlorinated aliphatic hydrocarbons behave very similarly; thus, their fate and transport will be discussed as groups.

5.2.1 Polycyclic Aromatic Hydrocarbons and Heterocyclic Compounds

The polycyclic aromatic hydrocarbons (PAHs) detected at the Ormet site can be categorized into one of five groups, based on structural presence of aromatic rings. There are five PAHs which have two aromatic rings: acenaphthene, acenaphthylene, fluorene, 2-methylnaphthalene, and naphthalene; three PAHs with three aromatic rings: anthracene, fluoranthene, and phenanthrene; six PAHs containing four aromatic rings: benzo(a)anthracene, benzo(b,k)fluoranthene, pyrene, chrysene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene; two PAHs containing five aromatic rings: benzo(a)pyrene and dibenzo(a,h)anthracene; and one PAH containing six aromatic rings: benzo(g,h,i)perylene.

PAHs generally sorb strongly onto soil particles and suspended particulates. In general, as molecular weight increases, water solubility tends to decrease; therefore, phenanthrene is more soluble in water than pyrene. Upon release to surface water, PAHs will be subject to photolysis, although the degree to which this process may be inhibited by the sorption of PAHs on to soils and organic matter is not known. Considering the consistent detection of PAHs in soil and solids samples from the potential source areas at the Ormet site at concentrations up to several thousand mg/kg, the low

solubility of PAHs and their affinity to sorb onto the matrix materials has greatly reduced the mobility of PAHs at the Ormet site. This is apparent from their absence at CLP-detectable levels in ground-water samples from the alluvial aquifer and from surface-water samples.

Biodegradation and biotransformation are the ultimate fate process for PAHs in soils and sediment. Data regarding half-lives in soils of most PAHs are not available in the literature. However, the degradation half-lives of phenanthrene and pyrene in two representative soils have been reported in the literature from 30 to 43 days for phenanthrene and from 35 to 50 days for pyrene (API, 1987).

Most organic compounds (including PAHs) are not broken down completely to carbon dioxide and water by bacteria, but are metabolized to intermediates which are in turn further degraded. In a laboratory study which evaluated the degradation of phenanthrene to low molecular weight carboxylic acids by soil *Pseudomonads* (bacteria), a total of 24 different metabolites were either isolated or proposed as intermediates (Pucknat, 1981). All of these intermediates are more water soluble than the parent compound and are therefore more mobile. Some of them are also more toxic.

Biodegradation rates vary widely, depending on such soil conditions as oxygen availability (aerobic vs. anaerobic), pH, contaminant concentrations, nutrient level, moisture content, temperature, and the microbial community. Under conditions of extreme pH (either acid or basic) and high contaminant-concentrations, microbial action can be inhibited or prevented. The extent to which the basic pH and contaminant concentrations at the Ormet site may inhibit the biodegradation processes is not known.

PAHs can be readily bioconcentrated; however, they are also rapidly metabolized and excreted in fish (Niimi and Palazzo, 1986; Niimi and Dookhran, 1989), such that bioaccumulation is not a long-term situation. The BCF values reported for the PAHs detected at the site range from 10.5 (naphthalene) to 1,150 (fluoranthene) (Table 92). Evidence indicates that clearance rates for most PAHs are rapid, with half-lives of nine days or less in fish (Niimi and Dookhran, 1989). Some species of invertebrates (e.g., bivalve mollusks) can bioaccumulate PAHs. This is presumably due to inefficient or missing mixed-function oxidase systems that can impair the ability of an organism to metabolize and excrete PAHs (Eisler, 1987). The dominant removal process for PAHs from water is associated with sorption to soil particles, suspended particulates, and sediments (Hickock et al., 1982). Once sorbed to soil particles and sediments, the mobility of PAHs would be limited, assuming that subsequent actions do not resuspend the sediments, which could affect transport of PAHs in surface water.

Compared with the amount of data available describing the fate and transport of polycyclic aromatic compounds, relatively little is known about heterocyclic biotransformation processes (Mueller et al., 1989). Under appropriate conditions, these compounds may be susceptible to microbial attack. Biodegradation of O-heterocyclic chemicals, such as dibenzofuran, is poorly characterized. Other fate and transport processes of dibenzofuran are similar to the processes of 2-ring PAHs, such as naphthalene.

5.2.2 Monocyclic Aromatic Hydrocarbons

The monocyclic aromatic hydrocarbons (MAHs) detected at the site include benzene, toluene, and chlorobenzene. These compounds are characterized by low water solubilities, moderate to high

vapor pressures and Henry's Law Constants, low BCFs, low to moderate $K_{oc}s$, and moderate $K_{ow}s$. Volatilization is the major removal mechanism from soil and surface water, and oxidation is a primary mechanism for atmospheric destruction of these constituents. (USEPA, 1979; Windholtz and Budavari, 1983; Howard, 1989).

The K_{oc} values for these constituents indicate moderate to high mobility in soil with chlorobenzene having the highest potential for adsorption.

Degradation of the MAHs is primarily a result of reaction with hydroxyl radicals in the atmosphere or hydroxylation and mineralization by a large number of bacteria and fungi found in the environment. Biotransformation studies involving benzene, toluene, and ethylbenzene in soils have indicated extensive biotransformation (measured as loss of parent compound); however, low concentrations persisted (with the exception of ethylbenzene which as degraded to non-detectable levels) after 4 weeks of incubation (Thomas et al.,1988). Chlorobenzene biodegradation is generally slow in soil and water (Howard, 1989), but studies have shown rapid biodegradation of this compound in soil leaving no detectable residues (Agency for Toxic Substances and Disease Registry [ATSDR], 1989a). The products of the hydroxylation of the MAHs would be phenolics, and the ultimate products of mineralization would be carbon dioxide, water, and, in the case of chlorobenzene, chloride ions. The extent to which this process of degradation may apply to the Ormet site is assumed to be insignificant in ground water but significant in surface water.

5.2.3 Chlorinated Aliphatic Hydrocarbons

The chlorinated aliphatic hydrocarbons detected at the Ormet site include chloroform, methylene chloride, tetrachloroethene (PCE), and 1,2-dichloroethene (1,2-DCE). These compounds generally have low aqueous solubilities and high vapor pressures (Table 92). In general, they have relatively low soil sorption, extremely slow hydrolysis rates, and relatively rapid oxidation rates (USEPA, 1979). Volatilization of chlorinated aliphatic hydrocarbons from surface soils and surface waters to the atmosphere, where rapid decomposition through photo- or chemical-oxidation takes place, is a potentially important removal process for these compounds.

Methylene chloride, which was detected in soil, ground water, and surface water, is relatively soluble in water, and has a half-life in ground water of 2 to 8 weeks (Howard et al., 1991). Methylene chloride's half-life in surface water is short (3 to 5 hours) because of its high vapor pressure (Howard, 1990). Studies have indicated that microbial degradation occurs in aquatic systems, yielding methyl chloride as a breakdown product, as well as complete mineralization to CO_2 and chloride ions (ATSDR, 1987). Little information concerning methylene chloride's biodegradability in soils is available.

The unsaturated compound tetrachloroethene (PCE) is moderately water soluble and is resistant to chemical and biological degradation. The half-life in ground water is from 12 months to 2 years (Howard et al., 1991). Besides volatilization, which is the major removal process, hydrolysis and biodegradation are the most important transformation processes in natural water and soil systems although neither process occurs rapidly (ATSDR, 1990a, 1989b). The biological transformation of PCE involves anaerobic, reductive dehalogenation yielding TCE isomers of dichloroethylene, and

vinyl chloride. The detection of 1,2-dichloroethene in the ground water at the Ormet site is likely to be evidence of the degradation of PCE. Oxidation and photolysis are not environmentally important degradation processes for PCE.

Chloroform has a relatively high water solubility compared to the other chlorinated aliphatics and is fairly mobile in soil and ground water. It will not hydrolyze significantly under normal environmental conditions, but several studies have indicated that slow aerobic and anaerobic biodegradation may occur.

5.2.4 Metals and Inorganics

The chemical variables which are primarily responsible for controlling metal speciation (the form of the molecule or ion in solution) are the redox potential (Eh) and acidity/basicity (pH) (Stumm and Morgan, 1981). Eh is a measure of the electrochemical potential of the ions present in either soil or water and determines the oxidation state of a metal. Metals may occur as aqueous species or may precipitate out of solution. The pH and Eh in water or soil at a site affect the degree to which the following mechanisms attenuate metals: adsorption by soil, particularly clays and colloids; precipitation or coprecipitation; adsorption to iron, aluminum, and manganese oxides; and complexation with organic matter and ion exchange.

The approved RI Work Plan did not require the characterization of background concentrations of metals and other constituents in soils not affected by waste materials at the Ormet site. The RI did include background determinations for metals and other constituents in river sediments (see sample RS-1 in Tables 45 and 46), surface water (see sample SW-1 in Tables 55 and 56), and ground water

(see sample MW-19 in Tables 64 and 66). These site-specific data are presented throughout the following discussions.

5.2.4.1   Aluminum

The reported background aluminum concentration in river sediments (sample RS-1) ranged from 8,670 to 9,980 mg/kg (Table 45). Although no site-specific background samples for soil were collected, USGS data collected at locations distant from the site, but characteristic of the region indicate that regional background concentrations (from Table 2-7 of the Baseline Risk Assessment [Donohue & Associates, 1992]) of aluminum range as high as 70,000 mg/kg (Donohue & Associates, 1992). The USGS regional background concentration is exceeded by the maximum concentrations of aluminum detected in samples from the Disposal Ponds (199,000 mg/kg), CRDA (107,000 mg/kg) and the CMSD (121,000 mg/kg) while the concentrations detected at the Potliner Storage Area were within the regional background range (Donohue & Associates, 1992). Aluminum has been detected at a geometric mean concentration of 5,840 mg/kg in positive soil samples from 2,783 National Priorities List (NPL) and non-NPL hazardous waste sites (ATSDR, 1990b). Aluminum is the third most common element in igneous rocks. It is a constituent of aluminosilicate minerals (e.g., clays) and of many silicate minerals (e.g., feldspar), which are common in the matrix of the alluvial aquifer beneath the Ormet site. In silicate lattices, aluminum can substitute for silicon in fourfold coordination, and in magnesium and iron sites in sixfold coordination. In sedimentary rocks, aluminum occurs as gibbsite [$Al(OH)_3$], less often as cryolite [Na_3AlF_6], and in alum, but most of all as a component of clay minerals. Its low geochemical mobility is clear from the low aluminum content of seawater (0.001 mg/kg). In aqueous solution, the cation Al^{3+} is predominant at pH values below 4.0, probably in the hydrate with six water molecules. In soils, the most soluble form of aluminum under low pH

conditions is nonsilicate organically bound aluminum. The most soluble form under high pH conditions is amorphous $Al(OH)_3$. With increasing pH, it appears that one of the water molecules becomes an OH^- ion, and at pH 4.5 to 6.5 polymerization starts, forming aluminum hydroxide complexes of various sizes, which form minute crystals with time. The polymerization of aluminum hydroxide is accelerated by the presence of silica, which at sufficient concentration leads to rapid precipitation of poorly crystalline clay minerals (Hem, 1970). At a pH greater than 8, $Al(OH)_4^-$ can become the dominant species, thus increasing the solubility of aluminum-bearing minerals under high-pH conditions.

The background aluminum concentration reported for Ohio River surface water (sample SW-1) ranged from 2.1 to 2.3 mg/L total (Table 55). In ground water, the background aluminum concentration (see MW-19) was reported at 8.3 mg/L (Table 64), which is higher than expected for the pH of this sample and may reflect the incorporation of suspended sediments in the sample. In ground water and surface water systems, aluminum solubility is controlled to a large extent by equilibrium with a solid phase such as $Al(OH)_3$ (ATSDR, 1990b). Changes in pH or concentrations of other solutes can shift the solubility of aluminum to increase dissolution or precipitation.

The BCF values for aluminum in brook trout are reported to range between 50 to 136 (USEPA, 1988c). Therefore, the potential for bioaccumulation of aluminum may be considered low to moderate.

5.2.4.2   Antimony

Antimony in the background river sediment sample (RS-1) ranged from <6.2 to 9.4 mg/kg (Table 45). Antimony was not detected or not analyzed for in background and reference area samples. Antimony was either not detected or not analyzed for in the regional background and reference area samples (Donohue & Associates, 1992). Antimony is present as the oxide or antimonite (+3) salt in most natural waters. In reducing environments, volatile stibine (SbH_3) may be formed. Stibine is a gas at room temperature, and it is quite soluble in water. However, it is not stable in aerobic waters or air and is oxidized to form Sb_2O_3. Biomethylation is a process which causes the formation of volatile stibine derivatives. It is clear that sorption to clays and minerals is normally the most important mechanism resulting in the removal of antimony from solution and reduces the aqueous transport of antimony. Heavy metals in solution also react with antimonite or antimonate (+5) to form insoluble compounds. Bioaccumulation appears to be only a minor fate process for antimony, with a reported BCF value of 1 (USEPA, 1991c).

The background antimony concentration reported for surface water in the Ohio River (sample SW-1) was less than 0.016 mg/L total (Table 55) and the background concentration reported in ground water (MW-19) was less than 0.025 mg/L (Table 64).

5.2.4.3 Arsenic

Arsenic occurs in many different forms and has a complex chemistry. Arsenic occurs in four valence states (-3, 0, +3, and +5) which are affected by pH and Eh. The +3 and +5 valence states are the most prevalent forms in minerals and natural waters. The 0, or metallic state exists in some mineral deposits, and the -3 state is present in arsine gas (USEPA, 1979). In ground water at the Ormet site having a pH from 7 to 11, the divalent arsenate ($HAsO_4^{-2}$) is the most likely aqueous species. In ground water having a pH from 3 to 7, the monovalent arsenate ($H_2AsO_4^-$) would be expected. Arsenic concentrations reported in the background river sediment samples (RS-1) ranged from 7.3 to 12 mg/kg (Table 45). The regional background arsenic concentration in soil is reported to range as high as 9.9 mg/kg (Donohue & Associates, 1992). The maximum concentrations of arsenic detected in the Disposal Ponds (123 mg/kg), Potliner Storage Area (25 mg/kg), CRDA (663 mg/kg) and CMSD (56.9 mg/kg) (Donohue & Associates, 1992) exceeded the regional background concentration.

In surface water, arsenic is very mobile and sediments serve as a reservoir. Sediment-bound arsenic under anoxic, reducing conditions may be methylated by microorganisms and released back into the water column. Methylated arsenic is less toxic than inorganic forms. Most animals and humans metabolically convert inorganic arsenic (III) to monomethyl arsenic (MMA) and dimethyl arsenic (DMA), with a decrease in toxicity corresponding to one order of magnitude for each added methyl group (ATSDR, 1989c). Methylation also results in efficient and rapid excretion of arsenic in the urine.

In soil, inorganic arsenic compounds are also methylated by fungi, yeasts, algae, and bacteria, resulting in the release of volatile methylated arsenic species to the atmosphere. The BCF ratios for arsenic in freshwater fish are listed at 44 (USEPA, 1991c). In general, bioconcentration of arsenic occurs in aquatic organisms, primarily in algae, but biomagnification in aquatic food chains does not appear to be significant (ATSDR, 1989c). Some fish and especially shellfish can accumulate substantial levels of arsenic which are toxicologically inert (ATSDR, 1989c).

The background concentration reported for arsenic in the surface water of the Ohio River (SW-1) was <0.004 mg/L total (Table 55) and in ground water (MW-19) was reported at 0.007 mg/L (Table 64).

5.2.4.4 Barium

Barium is a reactive metal that is not found free in the environment, but exists as a number of salts. The chief barium mineral found in nature is barite ($BaSO_4$). Barium salts are found in many types of rocks. Limestone, sandstone, and soils in the eastern U.S. contain 300 to 500 mg/kg of barium (Federal Register, 1985). The regional background barium concentration is reported to range as high as 700 mg/kg (Donohue & Associates). The concentrations of barium detected in samples from the Potliner Storage Area, CRDA, and CMSD were within the regional background range. The maximum concentration of barium detected in the Disposal Pond samples (840 mg/kg) exceeded the regional background concentration. In the background river sediments (sample RS-1), barium was reported at 116 to 142 mg/kg (Table 45).

Typically, the mineral forms of barium are relatively insoluble; although some salts of barium are soluble in water. However, barium ions are rapidly precipitated or removed from solution by adsorption and sedimentation (McKee and Wolf, 1963). Soluble barium concentrations would have to exceed 50 mg/L in fresh or marine waters to be toxic to the aquatic organisms; however, no aquatic criteria have been set for barium because most natural waters have sufficient sulfate and carbonate to precipitate the barium out of solution as a virtually insoluble, non-toxic compound (USEPA, 1986a). The mobility of barium in ground water will decrease as barium is precipitated out of solution by the carbonate and sulfate in the ground-water and surface-water systems. The background concentration of barium reported in the Ohio River (SW-1) was 0.065 mg/L total (Table 55) and in ground water (MW-19) was reported at 0.23 mg/L (Table 64).

The biologic half-life of barium is short (less than 24 hours) (Beliles, 1979). Soluble barium compounds that are absorbed are transported by the plasma and excreted via the feces. Plants accumulate barium from the soil although the reported uptake factor of barium from soil to edible plant parts is low (0.005) (U.S. Department of Energy [USDOE], 1989). Available information suggests that barium is not bioaccumulated in aquatic organisms. The BCFs for fish and shellfish are reported as 4 and 0.2, respectively (USDOE, 1989).

5.2.4.5   Beryllium

In the background river sediments (sample RS-1), beryllium ranged from 1.0 to 1.4 mg/kg (Table 45). The regional background concentration for beryllium in soil is reported to range up to 1.5 mg/kg (Donohue & Associates, 1992). The maximum concentrations of beryllium detected in samples from the Disposal Ponds (14 mg/kg), Potliner Storage Area (2.2 mg/kg), CRDA (7.8 mg/kg)

and CMSD (3.8 mg/kg) exceed the regional background concentration. Beryllium ions can replace silicon in silicate lattices, but the element also occurs in the mineral beryl, $Be_3Al_2Si_6O_{18}$. Beryllium oxide and hydroxide are slightly soluble; the concentrations of noncomplex-bound Be^{2+} in equilibrium is 0.001 to 1 $\mu g/L$. Complex hydroxide ions can raise the solubility a little, particularly at higher pH values. At low pH, beryllium ions are easily adsorbed onto clay minerals. Extremely low concentrations (<0.001 $\mu g/L$) of this element are to be expected in ground water, because of the low solubility of its compounds (Hem, 1970). Durfor and Becker (1964) found detectable beryllium in potable water (0.75 $\mu g/L$). The background concentration of beryllium reported in the Ohio River (SW-1) was <0.005 mg/L total (Table 55) and in ground water (MW-19) was <0.001 mg/L (Table 64).

Beryllium may be accumulated to a slight extent by aquatic organisms (USEPA, 1985a). It is also possible that benthic organisms accumulate beryllium from sediment and transfer it to higher organisms by the food chain. With a BCF of 19 (USEPA, 1991c), freshwater fish also accumulate beryllium.

5.2.4.6 Chromium

Chromium is a trace element and a natural component of soils and ground water. The regional background concentration of chromium in soil has been reported up to 100 mg/kg (Donohue & Associates, 1992). The maximum detected concentrations of chromium in soil samples from the Disposal Ponds and Potliner Storage Area (119 and 168 mg/kg, respectively) (Donohue & Associates, 1992) exceed the regional background concentration while the chromium concentrations in the CRDA and CMSD were within the regional background range. The background river sediment sample (RS-1) reported a chromium concentration of about 20 mg/kg (Table 45).

Chemical speciation is critical in determining the fate and transport of chromium. Chromium in soil or water exists in either a trivalent (Cr^{3+}) or hexavalent (Cr^{6+}) oxidation state, depending on the presence of oxidizing or reducing agents. Hexavalent chromium is soluble and often exists as a complex ion in solution. Adsorption to soil components is not a significant fate pathway of Cr^{6+} (USEPA, 1979). Hexavalent chromium reacts with reducing agents to form the less toxic trivalent chromium. Dominant fate processes of trivalent chromium include reaction with aqueous hydroxide ions to form an insoluble precipitate (chromium hydroxide) and adsorption of dissolved chromium to soil particulates and sediments (USEPA, 1979). Consequently, migration of trivalent chromium is limited due to strong adsorptive processes. The most likely form of chromium at the Ormet site is trivalent chromium.

The background concentration of chromium reported in the Ohio River water (SW-1) was 0.004 mg/L total (Table 55). In ground water, the background concentration of chromium was reported at 0.008 mg/L in MW-19 (Table 64).

The BCF for chromium in fresh water fish is listed at 16 (USEPA, 1991c). Chromium is also accumulated to a greater extent in algae and saltwater organisms.

5.2.4.7   Copper

The regional background copper concentration in soil is reported to range as high as 30 mg/kg (Donohue & Associates, 1992). The maximum concentrations of copper detected in the Disposal Ponds (130 mg/kg), Potliner Storage Area (791 mg/kg), CRDA (94 mg/kg), and CMSD (542 mg/kg) (Donohue & Associates, 1992) soil samples exceed the regional background concentration. In the

background river sediment sample (RS-1), copper was reported at about 29 mg/kg (Table 45). Copper exists in two oxidation states, Cu^+ (cuprous) and Cu^{2+} (cupric). Cuprous copper is unstable in aerated water over the pH range of most natural waters (6 to 8) and oxidizes to the cupric state. Several processes determine the fate of copper in water: formation of complexes, especially with humic substances; sorption to hydrous metal oxides, clays, and organic materials; and bioaccumulation (USEPA, 1985a). The BCF for copper in freshwater fish is reported as 36 (USEPA, 1991c). The presence of organic acids and acidic conditions may lead to the mobilization of copper from soils and sediments to solution.

Water chemistry determines the levels of copper able to remain in solution. The strong affinity of copper to sorb to organic matter and clays limits the mobility of copper and results in the enrichment of the solid phase and reduction in dissolved level. The background concentration of copper in the Ohio River (SW-1) was reported at 0.006 to 0.010 mg/L total (Table 55) and in ground water (MW-19) was reported at 0.019 mg/L total (Table 64).

5.2.4.8   Lead

Background concentrations of lead in surficial soils may range from less than 10 mg/kg to more than 500 mg/kg, with an average of about 20 mg/kg (USGS, 1984). The lead concentration in the background river sediment sample (RS-1) ranged from 17 to 20 mg/kg (Table 45). The regional background concentration of lead in soil is reported to range as high as 30 mg/kg (Donohue & Associates, 1992). The maximum detected concentrations of lead in the Disposal Ponds (214 mg/kg), Potliner Storage Area (74 mg/kg), CRDA (85 mg/kg), and CMSD (84.1 mg/kg) (Donohue & Associates, 1992) exceed the regional background concentration.   Anthropogenic sources have

contributed significantly to "background" levels over the past several decades. Gasoline combustion once accounted for about 90 percent of lead emissions to the atmosphere; however, due to significant reductions in the amount of organolead compounds used in gasoline, auto emissions are no longer the largest source of atmospheric lead. Organolead compounds have not been used at the Ormet site. Municipal waste incineration and primary lead smelting are the current major sources of lead emissions.

Atmospheric lead exists primarily in the particulate form and is removed by wet and dry deposition. The particulate size distribution affects atmospheric residence time and transport, with an average residence time of one to four weeks (USEPA, 1986a). Lead bromochlorides are the primary compounds released from automobile exhausts (USEPA, 1979; 1986a). Photolytic processes result in the release of halogens and the formation of lead oxide (PbO). Lead sulfate (PbSO$_4$) and lead sulfide (PbS) are primarily released from mining and smelting operations (USEPA, 1986b).

Organolead compounds are only marginally volatile and exist in the vapor phase; however, they rapidly decompose to more water soluble compounds and are removed from the atmosphere (USEPA, 1985b). Environmental exposure to organolead compounds is not likely to be significant.

Atmospheric fallout is the primary source of lead found in surface water. Lead tends to form insoluble compounds with the naturally-occurring anions in surface water (hydroxide, sulfide, carbonate, and sulfate) (USEPA, 1979). Lead and its compounds can also form complexes with organic matter or be adsorbed by soils and sediments. Precipitation may also be important in removing lead from water.

Solubility is dependent on the form of lead, pH, temperature, and salt content. At pH > 5.4, the total solubility of lead is approximately 0.03 mg/L in hard water and 0.5 mg/L in soft water (ATSDR, 1988a). Natural compounds of lead have low solubility; therefore, the ratio of lead in suspended solids to dissolved lead is high (USEPA, 1986b). Inorganic lead can be biomethylated to tetramethyl lead by benthic microorganisms. Tetramethyl lead can be released from sediments and removed by volatilization.

Inorganic lead is strongly sorbed and retained in the soil, depending on the species, pH, organic content, etc. Some lead compounds can leach in acid soils, if the organic or clay content is low. Organolead compounds are degraded in soil. Some lead may also be taken up by plants.

The background concentration reported for lead in the Ohio River (SW-1) was 0.005 mg/L total (Table 55) and in ground water (MW-19) lead was reported at 0.006 mg/L (Table 64).

Fish accumulate very little lead in edible tissue; accumulation is greater in non-edible fish tissue (e.g., fin, liver, gill) than in edible tissue (USEPA, 1979). The availability of divalent lead (the form accumulated by aquatic organisms) decreases as pH increases (USEPA, 1979). The reported BCF for fish is 49 (USEPA, 1991c); however shellfish, aquatic plants and some invertebrates have higher values (USEPA, 1979).

5.2.4.9 Manganese

Manganese is abundant in U.S. soils, and is also an important constituent of igneous rocks. The regional background concentration of manganese in soil is reported to range as high as 1,000 mg/kg (Donohue & Associates, 1992). The maximum detected concentrations of manganese in soil samples from the Potliner Storage Area (3,220 mg/kg), CRDA (2,140 mg/kg), and the CMSD (1,060 mg/kg) (Donohue & Associates, 1992) exceed the regional background concentration, while the maximum concentration from the Disposal Ponds (227 mg/kg) was within the regional background concentration range. The manganese concentration in the background river sediment sample (RS-1) was reported at 615 to 820 mg/kg (Table 45). Its relative rarity in seawater (0.004 mg/L) reflects its low geochemical mobility. Manganese (Mn^{2+}, Mn^{3+}, and $Mn^{4}+$) is widely distributed in sediments and soils as oxides, hydroxides and carbonates.

Manganese participates in plant metabolism and can be considerably accumulated in plant material. After leaf fall or on the death of plants, manganese is liberated again. Microorganisms play a catalytic role in the oxidation and reduction of manganese.

At about pH 7, Mn^{2+} is the dominant manganese ion. For pH values near 7 in oxygenated water, a manganese content between 1 and 10 mg/L may be expected. At higher pH values, the aqueous solution lies in the stability field of manganese oxides and manganese carbonate, in which the pH and Eh controls are complex. Manganese is detectable in minor amounts in most ground water. Generally, the manganese content of ground water is lower than the iron content, possibly because of its more limited geochemical abundance. The background concentration of manganese

reported for the Ohio River (SW-1) was 0.29 to 0.34 mg/L total (Table 55) and in ground water (MW-19) was 0.23 mg/L (Table 64).

5.2.4.10 Mercury

Mercury may occur in nature as the metallic form; however, the major commercial source is mercuric sulfide (HgS), which is known as cinnabar. The regional background mercury concentration in soil is reported to range up to 0.13 mg/kg (Donohue & Associates, 1992). The maximum concentrations of mercury detected in the Disposal Ponds (0.59 mg/kg) and CRDA (0.31 mg/kg) (Donohue & Associates, 1992) site samples exceed the regional background concentration, while the mercury concentrations reported for the Potliner Storage Area and the CMSD were within the regional background concentration range. The mercury concentration reported in the background river sediment sample (RS-1) was <0.12 mg/kg (Table 45). The major uses of mercury in the U.S. include the production of electrical apparatus, chloralkali apparatus, paint, dental preparations, pesticides, pharmaceuticals, and catalysts.

Mercury can be present in the environment in one of three oxidation states; Hg°, Hg^{+}, and Hg^{2+}. The most reduced form is the metal (Hg°). The mercurous ion (Hg^{+}) has an oxidation of +1, and the mercuric ion (Hg^{2+}), has an oxidation state of +2. Within a moderately oxidizing environment and a pH above 5, the predominant mercury species will be elemental mercury. Mildly reducing conditions, which are likely to occur in many sediments, can cause the mercury to be precipitated as the sulfide (cinnabar).

Mercury is strongly sorbed to many types of surfaces. In nature, a major portion of the total mercury has been found associated with particulates (Hinkle and Learned, 1969). Inorganic mercury is bound strongly enough by sediments to be transported by sediment mobilization. Mercury adsorption onto sediments is probably the most important process for determining the fate of mercury in water (USEPA, 1979).

Metallic mercury can enter the atmosphere as a result of volatilization. The rate of vaporization of inorganic mercury decreases in the sequence $Hg > Hg_2Cl_2 > HgCl_2 > HgS > HgO$ (Koksay and Bradshaw, 1969). Organomercury compounds are more volatile than divalent mercury. Methylation of mercury by microbial transformation can result in a net increase in the volatility of mercury.

The background concentration reported for mercury in the Ohio River (SW-1) was <0.02 μg/L total (Table 55). The background concentration of mercury reported in ground water (MW-19) was also <0.02 μg/L (Table 64).

BCFs for freshwater fish are reported to range from 1,000 to 5,500 for mercury (USEPA, 1991c). Methyl mercury is the form of mercury present in most fish tissue. Methyl mercury is readily accumulated by fish both from their food and through the water. Once mercury has entered the biological system, the depurative half-life of methyl mercury in aquatic organisms can be as long as one to three years (Phillips and Russo, 1978).

5.2.4.11   Nickel

Nickel is a naturally-occurring metal that is found in small quantities in the earth's crust and in all parts of the environment, including plants and animals used for human consumption, air, drinking water, rivers, lakes, oceans, and soils. Natural nickel concentrations in soils depend on the mineral constituents of the soil. The regional background concentration of nickel is reported to range up to 30 mg/kg (Donohue & Associates, 1992). The maximum detected concentrations of nickel in the Disposal Ponds (656 mg/kg), Potliner Storage Area (146 mg/kg), CRDA (558 mg/kg), and CMSD (62.5 mg/kg) (Donohue & Associates, 1992) site samples exceed the regional background concentration. The nickel concentration in the background river sediment sample (RS-1) was reported at 26 to 32 mg/kg (Table 45).

Nickel is usually divalent in its compounds, which are predominantly ionic in character. Nickel forms compounds with sulfate, chloride, nitrate, carbonate, oxide, hydroxide, and organic ligands (Cotton and Wilkenson, 1972). Under reducing conditions and in the presence of sulfur, the insoluble sulfide is formed. Under aerobic conditions and pH below 9, the compounds nickel forms with hydroxide, carbonate, sulfate, and naturally occurring organic ligands in natural waters are sufficiently soluble to maintain aqueous Ni^{2+} concentrations above 60 μg/L (USEPA, 1979).

Humic acids in natural waters will alter the solubility and precipitation behavior of nickel. Humic acids are ubiquitous in natural waters and may be expected to increase the solubility of nickel under natural conditions. Adsorption processes can scavenge nickel from solution (USEPA, 1979). In natural waters, adsorption processes are moderately effective in limiting the mobility of nickel.

The background concentration reported for nickel in the Ohio River (SW-1) was from <0.007 to 0.008 mg/L total (Table 55). In ground water, the background concentration reported for nickel at MW-19 was <0.026 mg/L (Table 64).

In a study of the accumulation of iron, zinc, lead, copper, and nickel by algae collected near a zinc smelting plant, it was found that nickel exhibited the lowest bioconcentration factor of all the metals tested (Trollope and Evans, 1976). The reported fish BCF for nickel is 47 (USEPA, 1991c).

5.2.4.12 Vanadium

The regional background concentration of vanadium in soil is reported to range up to 70 mg/kg (Donohue & Associates, 1992). The maximum concentration of vanadium detected in the Disposal Ponds (741 mg/kg) and the CRDA (270 mg/kg) exceed the regional background concentration, while concentrations detected in the Potliner Storage Area and the CMSD were within the regional background concentration range. The vanadium concentration reported in the background river sediment sample (RS-1) was about 18 mg/kg. Vanadium is often present in magmas as a minor element, mainly as a minor constituent in magnetite, pyroxene (especially aegirine), amphibole, and biotite. It is concentrated in sulfide deposits, mainly as patronite (VS_4), in oxidized sulfide ores in the form of various vanadates, in muscovite, and in oxide deposits in sandstones, mainly as montroseite [(V,Fe)O·OH] (Wedepohl, 1978).

Vanadium occurs in solutions as anionic and cationic species. The V^{3+} and V^{4+} species are soluble only up to approximately 1 μg/L (Hem, 1970). Vanadium is removed from solution by adsorption, (Krauskopf, 1956). In oxygenated ground water, measurable vanadium values can be

found and concentrations as high as 70 µg/L have been observed (Durfor and Becker, 1964; Hem, 1970). The background concentration for vanadium reported in the Ohio River (SW-1) was <0.006 mg/L total (Table 55) and in ground water (MW-19) was 0.015 mg/L (Table 64).

5.2.4.13   Zinc

Zinc can occur in both dissolved and precipitated forms in the environment. The regional background concentration of zinc is reported to range up to 50 mg/kg (Donohue & Associates, 1992). The maximum concentrations of zinc detected in the Disposal Ponds (170 mg/kg), Potliner Storage Area (109 mg/kg), CRDA (194 mg/kg), and CMSD (125 mg/kg) (Donohue & Associates, 1992) site samples exceed the regional background concentration. The zinc concentration in the background river sediment sample (RS-1) was reported at 118 to 132 mg/kg (Table 45). Dissolved zinc may occur as the free (hydrated) zinc ion or as dissolved complexes. Precipitated zinc may be dissolved following changes in water chemistry or may be sorbed to suspended matter (USEPA, 1985a). Sorption of the divalent zinc cation by hydrous iron and manganese oxides, clay minerals, and organic material is the predominant fate of zinc in aerobic soil and water systems. Precipitation of zinc sulfide limits the mobility of zinc in reducing (anaerobic) environments (USEPA, 1985a). Zinc is an essential element that is bioaccumulated to some extent. The BCF of zinc in freshwater fish is reported at 47 (USEPA, 1991c). Zinc does not, however, appear to be biomagnified (USEPA, 1985a). The background concentration reported for zinc in the Ohio River water (SW-1) was 0.032 to 0.042 mg/L total (Table 55). In ground water, the reported background concentration in MW-19 was 0.139 mg/L (Table 64).

5.2.4.14 Cyanide

The fate and transport of cyanide (CN⁻) in environmental media is dependent on the physical and chemical properties of the inorganic or organic compound that contains the cyanide ion. Cyanide occurs in the environment in many forms, some of the more common of which include hydrogen cyanide (HCN), alkali metal cyanide (e.g., NaCN), organic cyanide (nitriles), and heavy metal cyanide complexes [e.g., $Zn(CN)_2$, $Fe(CN)_6^{-3}$]. The total (CLP) cyanide concentration reported in the background river sediment sample (RS-1) was <0.71 mg/kg (Table 45). The background concentration of total (CLP) cyanide in the Ohio River water (SW-1) was reported at <0.005 mg/L (Table 55). In ground water, the background concentration of total (CLP) cyanide reported at MW-19 was <0.010 to 0.20 mg/L (Tables 64 and 77).

The ultimate fate process of cyanide as hydrogen cyanide and as nitriles is volatilization from surface water. Biodegradation is an important fate process in soil, sediment, and water (USEPA, 1979). Hydrogen cyanide and the nitriles may be biodegraded in ground water by various microorganisms. Once released to surface water,
cyanide compounds from ground water would volatilize or biodegrade relatively quickly. The free cyanide ion (CN⁻) may come to solution from the dissociation of alkali metal cyanide and may form complexes with heavy metals (ATSDR, 1989d).

Fate and transport processes of cyanide in water, sediment, and soil are dependent on the pH. At pHs less than 9.2, volatilization of hydrogen cyanide and nitriles would be the dominant fate process in surface water and soil. Transport of non-gaseous cyanides is expected to be minor in soils.

Biodegradation would occur in deeper water and soils, and in sediments. The complex heavy metal cyanide would be less mobile, due to adsorption to organic materials.

5.2.4.15   Fluoride

The fluoride concentration reported in the background river sediment sample (RS-1) was 5.3 to 6.8 mg/kg (Table 46). Fluorite (CaF_2) and apatite ($Ca_5(F,Cl) (PO_4)_3$]) are natural constituents of igneous and sedimentary rocks. Amphiboles and micas of natural soils contain fluoride substituting for hydroxyl groups, because the ionic radii are similar and the electric charges are the same. Fluoride is commonly found bounded to mineral surfaces in the place of hydroxyl ions. However, with increasing pH, it can be displaced by hydroxyl ions.

Fluoride in water forms soluble complexes with aluminum, beryllium, and ferric iron. The fluoride content in the presence of calcium is controlled by the solubility product of fluorite, CaF_2 ($10^{-10.57}$ at 25°C). The background concentration of fluoride reported in the Ohio River (SW-1) was <0.1 to 0.1 mg/L (Table 56) and in ground-water was 0.5 to 0.7 mg/L (Table 66 and 77). Data regarding fluoride bioaccumulation are not available.

5.2.5. Other Organics

5.2.5.1 Carbon Disulfide

Carbon disulfide has a moderate solubility, a high vapor pressure, and a low soil sorption (Table 92). Therefore, carbon disulfide is relatively mobile in soils. Volatilization and photo-

oxidation are the primary fate processes for carbon disulfide. Bioaccumulation is not significant (USEPA, 1986c).

5.2.5.2   Bis(2-ethylhexyl)phthalate

Sorption and biodegradation are the primary fate and transport mechanisms affecting bis(2-ethylhexyl)phthalate. Leaching is usually not significant due to sorption and low water solubility (Tables 92 and 93). Volatilization of bis(2-ethylhexyl)phthalate is low, and biodegradation is rapid, especially under aerobic conditions (half-life of 2 days to several weeks). Under anaerobic conditions prevailing in sediments and ground water, it is relatively resistant to degradation. Bis(2-ethylhexyl)phthalate may bioconcentrate in aquatic organisms (USEPA, 1979; Howard, 1989).

5.2.5.3   2-Butanone

2-Butanone has a high water solubility and a high vapor pressure, and a low K_{ow}, so sorption to soil and sediments is probably not significant. The predominant fate processes for 2-butanone are biodegradation and oxidation. With an estimated half-life in air of about 14 hours and an estimated half-life in soil and water of a few days, 2-butanone does not persist in the environment (USEPA, 1985a).

5.2.5.4   PCBs

Volatilization, sorption to soils and sediments, bioaccumulation, and anaerobic and aerobic dechlorination are the major processes determining the environmental fate and transport of PCBs.

Because of differences in physical and chemical properties among the various PCB congeners, PCB mixtures detected in the environment differ from the original commercial mixtures. PCBs in air samples contain a higher proportion of the lesser chlorinated congeners than those found in sediments or soils. Congeners found in biota generally contain a higher percentage of the more chlorinated congeners (USEPA, 1979). Environmental cycling of PCBs occurs through volatilization, air transport, fallout with dust and rain, and revolatilization. This cycling process has distributed PCBs throughout the environment (Swackhamer and Armstrong, 1986; Larsson, 1985).

Volatilization of PCBs from water is significant because of low solubility and a relatively high Henry's Law constant (Tofflemire et al., 1983). Volatilization was suggested to be the major route of PCB release from lakes by Swackhamer and Armstrong (1986). However, sorption to suspended sediments will reduce volatilization rates significantly.

Table 92 shows that PCBs have low water solubilities and high octanol/water partition coefficients (K_{ow}). This results in a high affinity of PCBs for soil and sediment. PCBs will strongly sorb to soil and sediments with relatively high organic matter or clay contents (USEPA, 1979; Haque et al., 1974). Significant leaching of PCBs from soils to ground water would not be likely under most conditions. Sediments act as sinks for deposition of PCBs; however, resuspension and resolution can result in volatilization (Fisher et al., 1983; Swackhamer and Armstrong, 1986). The congeners with higher chlorine content generally have the highest affinity to sorb to the organic matter and clays of soils and sediments, because they have lower solubilities and higher K_{ow}s compared to the congeners with lower chlorine content.

BCFs for PCBs range between 10^4 and 10^6 (USEPA, 1979). PCBs can be passed along the food chain or absorbed directly from the water column by aquatic species (Muir et al., 1988; Oliver and Niimi, 1988). PCB concentrations have been demonstrated to increase with trophic level and lipid content of the organism. The chlorine content of PCBs also increases with trophic level (Oliver and Niimi, 1988).

PCB congeners with less than five chlorine atoms are susceptible to biodegradation, while those with more than five, such as Aroclor 1248 that was detected at the Ormet site, are generally resistant (USEPA, 1979). Recent studies have shown that reductive dechlorination of the higher chlorinated congeners can occur in aquatic sediments. The dechlorinated products formed are generally less toxic and are subject to aerobic biodegradation (Quensen et al., 1988; Brown et al., 1987).

PCBs were not detected in background sediment or ground-water samples.

5.3   Constituent Mobility

5.3.1 Mobility of Organic Constituents

The mobility of organic constituents detected at the Ormet site in the subsurface environment is influenced by (1) chemical and biological processes, (2) the site-specific environmental conditions, and (3) the chemical composition of the industrial waste products themselves. The simultaneous presence of numerous interactive mechanisms and environmental conditions makes it difficult to describe the migration potential of a given constituent in a specific hydrogeologic setting.

In general, the mobility of the organic constituents at the Ormet site is determined by their solubility, sorptive ability (K_{ow} and K_{oc}), and Henry's Law Constant. These are influenced by pH, redox potential, climatic factors, soil composition, and microbial population. Unfortunately, there is a lack of information available in the literature to make generalizations about the mobility of the constituents. Usually, if an organic constituent is highly biodegradable, it will not be highly mobile. The relative mobility of constituents can be addressed by evaluating their solubility, K_{ow}, K_{oc}, and Henry's Law Constant jointly.

Overall, the organic constituents present in soil at the Ormet site are likely to volatilize and undergo photo- or chemical-oxidation. Among the numerous ground-water samples collected from the monitoring wells at the Ormet site, only very few samples showed detectable levels of organics. Organic constituents dissolved in ground water will degrade very slowly. Upon release from the ground water environment, organic constituents will volatilize and degrade through photo- or chemical-oxidation. The importance of volatilization as a migration pathway in soils decreases with

increasing depth below the surface. Excavation or other activities which disturb the subsurface soils will increase the rate of volatilization from the deeper soils.

Some of the organics at the site (PAHs, PCBs) are classified as semi-volatile compounds. The relatively low volatilization rates and water solubilities, and high sorption affinities of the PAHs make these compounds relatively immobile in environmental media. For PCBs in surface water, volatilization is significant because of low solubility and a relatively high Henry's Law constant (Tofflemire et al., 1983). However, high sorption affinities of PCBs for soil and sediments significantly reduce volatilization rates and the tendency for leaching of PCBs from soils to ground water.

5.3.2 Mobility of Inorganic Constituents

The inorganic constituents at the Ormet site include metals and cyanide (Table 92). The mobility of these constituents is determined primarily by their solubility and sorptive ability, which, in turn, are dependent on pH, redox potential, climatic factors, and soil composition. Metal cations appear to be relatively immobile, with the exception of aluminum which is subject to increased mobility at a pH greater than 8. Anions, such as chromate and cyanide, appear to be relatively mobile in soils (USEPA, 1979). However, the mobility is site (waste chemistry and environment) specific. The mobility of inorganic constituents is influenced by the redox state, ionic strength, ionic speciation, and ion exchange capacities, as determined by the hydrated ionic radius.

The following factors influence mobility of the inorganic constituents at the Ormet site:

1. Mobility of metals are decreased by the presence of some anions, such as carbonate phosphate, sulfate, and sulfide. Data collected at the Ormet site indicate the availability of these anions (Geraghty & Miller, Inc., 1988).

2. Metallic ions generally are more soluble and mobile in acid/reducing conditions. The neutral to basic pH prevailing in soils and ground water at the Ormet site immobilizes the heavy metals and facilitates their removal from solution. An exception is aluminum, which becomes more soluble and more mobile at a pH greater than 8.

3. Metals of one valence state can be more mobile than the same metal in a different valence state, due in part to the formation of soluble metal complexes.

Metals can be mobile in the subsurface environments when strongly acidic conditions exist. Soil and ground-water chemistry data generated during the RI indicate basic pH conditions and the presence of carbonates and sulfates, which will tend to limit the mobility of metals at the Ormet site. Numerous researchers have shown that the mobility of most metals is reduced as pH increases (Bohn et al., 1979; LaBauve et al., 1988; Evans, 1989). A drastic reduction in metal mobility occurs at neutral to basic pH, with aluminum being a notable exception as it becomes more soluble at a pH greater than 8. In fact, plants exhibit metal (nutrient) deficiency at basic pHs (Bohn et al., 1979).

Based on the relatively high pH values obtained for the suspected source materials at the Ormet site (e.g., pH values are typically between 7.0 and 9.6), metals contained in these materials (with the

exception of aluminum) would be expected to be relatively immobile. The results of ground-water monitoring at the Ormet site showed mean metal concentrations of <0.3 mg/L for antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, vanadium, and zinc, which is consistent with the predicted low mobility of these metals.

Biodegradation in surficial soil of styrene has also been shown to occur (Howard, 1989).

The saturated compounds 1,1,2,2-tetrachloroethane (1,1,2,2-PCA) and 1,1,1-trichloroethane (1,1,1-TCA) have generally been shown to be recalcitrant to biodegradation in natural aquatic systems (ATSDR, 1988b, 1989e). Of these compounds, only 1,1,1-TCA was detected in ground water (neither compound was detected in surface water). Both compounds undergo hydrolysis at environmental pHs; hydrolysis of 1,1,2,2-PCA forms trichloroethene, and 1,1,1-TCA forms 1,1-dichloroethene and acetic acid (ATSDR, 1988b, 1989e). Little information concerning the biotic or abiotic degradation of 1,1,2,2-PCA or 1,1,1-TCA in soil is available.

5.4   Release Source Analysis

Five areas of potential concern have been identified at the Ormet Corporation facility based on plant history and soil, seep water, ground-water, sediment, surface-water, and air sampling data. These areas are designated as: (1) former disposal ponds area; (2) CMSD; (3) former spent potliner storage area; (4) CRDA; and (5) the recreation fill area. The eastern portion of the facility, in which the potential source areas are located, is not readily accessed from the active production area and plant parking lots. With the exception of maintenance personnel, plant employee access to the eastern portion of the facility is limited to company picnics at the recreational area.

Available records indicate that the five former disposal ponds (1, 2, 3, 4, and 5), received, at various times from 1958 to 1981, sludges from the former air emissions wet scrubbing system (in Ponds 1 through 4) and tailings from the cryolite-recovery plant (in Pond 5). In general, analyses of waste-sludge samples from Ponds 1 through 4 reported the presence of cyanide, fluoride, chloride, sulfate, a variety of metals (including arsenic, calcium, chromium, copper, iron, lead, nickel, and vanadium), PAHs, and low levels of VOCs. Constituents detected in sludge samples from former Pond 5 exhibit similarities to the constituents found in the other disposal ponds, with the exception of total cyanide, aluminum, and chloride. In general, concentrations reported in samples from Pond 5 were higher than those reported in the other samples from Ponds 1 through 4.

Currently, there is some vegetative covering on the surfaces of the five disposal ponds. The potential exists for direct contact with the surficial waste material/soil matrix in these disposal areas. Releases from the ponds are possible as a result of precipitation infiltration, precipitation runoff (overland), and air emissions of particulates (fugitive dust). Ponds 1 through 4 have more vegetation

GERAGHTY & MILLER, INC.

and more surface crusting than Pond 5; therefore, Ponds 1 through 4 have a lower potential for fugitive dust generation than Pond 5. The permeability of the waste material in the ponds is relatively low. Therefore, evaporation of a large percentage of the precipitation is expected due to slow infiltration rates. Leaching from the ponds is reduced due to the low infiltration rates. Although, the results of infiltration tests performed on the pond surfaces may have no correlation with infiltration velocities below the surface of the ponds. Consequently, the results of the infiltrometer tests cannot be used to predict the velocity of water or dissolved solids movement through the pond solids. Due to the presence of earthen dikes, surface runoff from the ponds does not occur.

The former spent potliner storage area has some vegetative ground cover. Infiltration of precipitation through soils in this area is considered to be a much more significant source of ground-water alterations in the alluvial aquifer than other areas at the site. The spent potliner material has been removed so the majority of the past source of constituents in the ground water has already been remediated. In addition to the indicator parameters (calcium, sodium, fluoride, ammonia-nitrogen, pH, and total cyanide), various metals (including aluminum, arsenic, chromium, copper, lead, and nickel) were detected in surficial and subsurface soils. PAHs were also detected in the former spent potliner storage area soils, as well as low levels of several other semi-VOCs and three VOCs commonly associated with laboratory cleaning procedures (methylene chloride, acetone, and 2-butanone). Direct contact with surficial soil in the former potliner storage area is possible, although access to this area (and the other four potential source areas) is limited. The potential for fugitive dust emissions is low due to the surface crusting and presence of non-erodible surface materials. These areas are located in the eastern portion of the site, removed from the active production area, and normal plant activities do not require employee access to this area.

The CMSD received assorted waste construction materials and other miscellaneous plant debris for approximately 13 years (from 1966 to mid-1979). The CMSD is located in the southeastern corner of the site, adjacent to Pond 5. PAHs, PCBs, cyanide, fluoride, and several metals (including somewhat high levels of aluminum, arsenic, copper and sodium) were also detected in samples from the CMSD, as well as low concentrations of several VOCs. The CMSD is covered with indigenous vegetation (e.g., grass and shrubs), limiting the potential for direct contact. The vegetation also restricts releases of particulates to the air (fugitive dust) or water (erosion).

The occurrence of five seeps which emanate from the southwest base of the CMSD are believed to be the result of precipitation infiltration through the relatively permeable materials disposed of in the dump. The precipitation likely percolates downward through the CMSD materials until reaching the underlying native soil, which is a low-permeability silt and clay formation. The seep water is then diverted laterally to the discharge points. The analytical data indicate that the water emanating from the seeps contains cyanide, fluoride, sulfate, iron, sodium, several other metals, and low concentrations of a few VOCs and semi-VOCs. The PCB Aroclor 1242 was detected at low concentrations in samples from two of the seeps.

Once discharged from the CMSD, the seep water follows the natural topography and flows overland a short distance to the Ormet National Pollutant Discharge Elimination System (NPDES) Outfall 004 backwater area. Waters from the NPDES Outfall 004 discharge to the Ohio River.

The CRDA is located in the southwest portion of the site near the Ohio River. This is an area where stormwater runoff (in the past) deposited carbonaceous material from the anode crushing mill. Several metals, cyanide, PAHs, a few semi-VOCs, and low concentrations of several VOCs were

detected in soil samples from the CRDA. The CRDA is covered with trees and thick undergrowth. Thus, the potential for direct contact with materials in this area is low. The potential for fugitive dust emissions from the CRDA is considered low due to the presence of dense vegetation on and around this area. Surface runoff from the CRDA follows the natural topography and enters the Outfall 004 backwater area.

The plant recreation fill area is located in the northeast portion of the site adjacent to the Ormet baseball field. A relatively small amount of rubble was deposited on the face of a slope leading down to the baseball field. Two seeps which discharge from the base of this slope appear to be the result of precipitation, infiltration, and percolation through the northeast corner of Pond 5. Cyanide, several other inorganics (including fluoride, iron, sodium, and sulfate), and low levels of a few VOCs were detected in the seep samples. The seep water drains east along the north edge of the baseball field for several hundred feet, then enters a small backwater area of the Ohio River.

The plume of affected ground water has been well defined (via the monitoring-well network) and is confined well within the Ormet property boundaries. The current ground-water pumping regime at the facility contains the affected ground water on-site.

Fugitive dust is a potential release mechanism, from the former disposal ponds and the former spent potliner storage area. Monitoring of respirable dust (particulates) was conducted at four locations on site for a 10-month period. Depending on the wind velocity and duration and particle size, off-site migration of fugitive dust is possible. The monitoring data and a computer model were used to calculate dust concentrations on-site and off-site.

Data from surface water and sediments collected in the 004 backwater area and at locations
adjacent to the site indicate above background levels of PAHs, various metals, cyanide, and PCBs,
particularly in the 004 backwater area sediments. This suggests that stormwater runoff and/or seep
discharge have acted as constituent-release mechanisms to the 004 backwater area.

6.0   BASELINE RISK ASSESSMENT

6.1   Overview

A baseline risk assessment (BRA) was conducted by Donohue & Associates (1992) on behalf of the USEPA for the Ormet Site. The purpose of the BRA was to evaluate the potential adverse environmental and public health effects (current and hypothetical future) resulting from actual or potential releases of hazardous substances at the Ormet Site under the no-action remedial alternative. The results of the BRA identify the magnitude of risk at the Site and are one criteria used to determine if remedial action is warranted.

The results of the BRA are discussed in detail in the two reports entitled, "Baseline Risk Assessment, Human Health Evaluation, Ormet Corporation, Hannibal, Ohio," and, "Baseline Risk Assessment, Environmental Evaluation, Ormet Corporation, Hannibal, Ohio. These reports were prepared by Donohue & Associates, and are provided as Appendix R to this report. At the request of USEPA, this section of the RI Report is a reiteration of the Executive Summary portion of the Human Health Evaluation report. The Donohue & Associates Executive Summary was incorporated virtually verbatim. The only modifications that were made were those needed to make the Executive Summary conform with the overall structure of the RI Report (e.g., table numbers and references were changed, as needed, and references to later sections of the BRA report were altered to reference the BRA report in Appendix R of the RI Report).

6.1.1 Background and Purpose

The Ormet Corporation site is located in southeastern Ohio along the Ohio River. The site is located at approximately river mile 123, about 35 miles south of Wheeling, West Virginia and approximately three miles upriver from Hannibal, Ohio (Monroe County). The site is bounded on the northwest by Ohio State Route 7, on the east of southeast by the Ohio River and on the southwest by the Consolidated Aluminum Corporation. (CAC).

Ormet produces aluminum metal from the reduction of alumina. The process utilizes electrolytic cells or pots, lined with anthracite and pitch. This material, referred to as potliner, deteriorates during the process and is eventually replaced. Between 1958 and 1968, this spent potliner was stored in an unlined, open area, approximately ten-acres in size, in the northeast area of the site.

From 1958 until 1981, five retention ponds were utilized to receive wastes from the facility. These ponds are unlined and constructed of natural materials. Ponds 1 through 4, each about one acre in size, received predominately sludge from the pot-room wet scrubbing system or the wet scrubber for the anode bake furnace. Ponds 1 through 4 may have also received minor amounts of tailings from the cryolite recovery plant which began operations in 1968. These four ponds range in depth from four to 13 feet. The 11-acre Pond 5 received mostly tailings from the cryolite recovery operation and may initially also have received sludge from the pot-room wet scrubber.

From 1958 through 1979, Ormet periodically deposited waste construction material in an area in th southeastern corner of the site. This four- to five-acre area is designated as the Construction Material Scrap Dump (CMSD). In the southeastern areas of the site there is an area referred to as the

Carbon Runoff and Deposition Area (CRDA). This three-acre wooded area contains deposits and carbon material one- to five-feet thick. The material has been carried from the anode crushing mill to the CRDA via storm water runoff.

The various site areas and their characterization are described in detail in previous sections of this report.

The BRA report (see Appendix R) provides an analysis of the potential adverse health effects (current and future) resulting from releases of hazardous substances at the Ormet Corporation Site. This evaluation, together with the Environmental Evaluation comprise the endangerment assessment, or baseline risk assessment, for the Ormet site. By definition, a baseline risk assessment is limited to conditions under the no-action alternative, that is in the absence of any remedial actions (including institutional controls) to control or mitigate releases.

6.2   Selection of Chemicals of Potential Concern

A large volume of monitoring data has been generated at Ormet. The data were organized and evaluated to select chemicals that form the basis for a quantitative risk assessment. These are referred to as the chemicals of potential concern. Many chemicals were analyzed for in the Ormet data set; some were eliminated from the quantitative risk assessment according to the following decision rules:

- Any chemical not detected in any sample was eliminated.

- Any chemical detected infrequently was eliminated if it was not expected to contribute significantly to risk.

- Beneficial nutrients present at levels expected to pose no excess dose or risk were eliminated.

- Chemicals detected but believed to be due to laboratory or field contamination were eliminated from the risk assessment.

- Any tentatively identified compound was eliminated.

- No chemicals were eliminated based on a comparison with background concentrations.

Table 95 summarizes the chemicals of potential concern that remain after these evaluations on an area-by-area basis at the Ormet site. The risk assessment focuses on these contaminants.

6.3   Exposure and Toxicity Assessments

An exposure assessment was performed which identified the current and potential future exposure scenarios to be used in risk characterization. Tables 96 and 97 indicate which pathways were selected for quantitative risk characterization.

A toxicity assessment was performed which documented potential adverse health effects for each contaminant of potential concern. Toxicity values (reference doeses and slope factors) were obtained from USEPA databases.

6.4   Risk Characterization

Risk characterization integrates the results of the exposure and toxicity assessments into a quantitative description of cancer and noncancer risks. The method for risk characterization utilized in this baseline risk assessment in consistent with U.S. Environmental Protection Agency guidelines as contained in the Risk Assessment Guidance for Superfund, Volume 1 - Human Health Evaluation and other material as contained in Section 7.0 of the Baseline Risk Assessment Report (see Appendix R).

6.4.1 Cancer Risks

The risk of cancer from exposure to a chemical is described in terms of the probability that an individual exposed for his or her lifetime will develop cancer. Estimated cancer risks are summed across all chemicals of potential concern and all potential exposure pathways that contribute to exposure of an individual in a given population. Typically, cancer risks of 1E-06 (one in one million) or lower are considered to be so small that they are of no practical significance. Higher cancer risk levels may be cause for concern. Due to the inherent uncertainty in cancer risk calculations, all risk values are reported to only one significant figure.

Table 98 summarizes cancer risk estimates for current exposure scenarios evaluated at Ormet. The only off-site current exposure scenario which appears to be of concern is fish ingestion. The estimated cancer risk calculated for the fish ingestion scenario (1E-01) is due almost entirely to PCBs (Aroclor 1242). Considerable uncertainties, described in both the exposure assessment and uncertainty sections of the BRA report (Appendix R), exist regarding this calculation. Conservative assumptions were used in attempting to quantify fish ingestion. Whether people in the area actually eat significant

numbers of fish caught in the Ohio River in the vicinity of Ormet was not determined for this risk assessment. Additionally, one river water sample used in the exposure point calculation (the sample which contained the PCBs) was taken in the area of the 004 discharge to the Ohio River. The sampling location was within an oil sheen on the river and is more indicative of the seep than the river water. Moreover, this sample does not account for the effects of river dilution and therefore is not indicative of the entire river.

The only current on-site exposure scenarios which appear to be of concern are those involving the hypothetical trespasser. Incidental ingestion of and dermal contact with sediments in the backwater area pose the highest risks. This is due primarily to PAHs and PCBs (Aroclor 1248). The lower estimated potential cancer risk for the hypothetical trespasser along the river bank is also attributable to PCB and PAH contamination.

Table 99 summarizes potential cancer risk estimates for all hypothetical future scenarios except future residential soil ingestion scenarios. Risk from ingestion of the groundwater, either in a no-pumping scenario or in a future drinking water well scenario, poses potential risk estimated at 5E-04 to 2E-03. Arsenic, beryllium and tetrachlorehylene are the contributing chemicals. If a future residence were built just downwind of Pond 5, potential cancer risk of 7E-06 might occur from particulate inhalation. Arsenic, chromium and PAHs are the contributing chemicals.

As for the current resident, any future residential ingestion of fish from the river might be expected to pose potential cancer risk (1E-01) due to PCBs (Aroclor 1242) detected in the river water. Other exposure scenarios that might pose potential risk are ingestion of and dermal exposure to river

sediments either along the river or in the backwater area. This is due primarily to the presence of PCBs (Aroclor 1248) and PAHs.

As shown in Table 100, estimated cancer risks (for exposure to soil) calculated at each of the exposure points where a future residence might be built, range from 3E-04 to 7E-03. The contributing chemicals include arsenic, beryllium, PAHs and the PCBs, (Aroclor 1248). It should be remembered that dermal exposures to PAHs cannot be quantified because of a lack of an appropriate toxicity value. Since many PAHs are carcinogenic by the dermal route, these risk calculations are likely to underestimate total risk from PAHs in these scenarios.

6.4.2 Evaluation of Noncarcinogenic Effects

The potential for noncarcinogenic effects is evaluated by summing hazard quotients (HQs) (the ratios of chemical-specific intakes over a specific time period to the chemical-specific RfDs derived for a similar exposure period). The sum of HA values is referred to as a hazard index (HI). Since some individuals are exposed by more than one pathway, HI values are summed for each pathway that contributes to the exposure of an individual in a given population. If the total HI is equal to or less than one (1E+00), it is believed noncarcinogenic health effects will not occur.

Values for subchronic (HI_s) and chronic (HI_c) exposures were calculated for each assumed exposure scenario evaluated at this site. Because of the uncertainty inherent in these calculations, all values are reported to only one significant figure.

As shown in Table 101, no hazard indices calculated for assumed current exposure scenarios exceed 1E+00. However, as shown in Tables 102 and 103, some hazard indices may exceed one for assumed hypothetical future scenarios. In a hypothetical future no-pumping scenario, HIs calculated for the groundwater ingestion pathway both for future workers and future residents could range from 20 to 600. Fluoride accounts for nearly all of this potential risk, although cyanide, arsenic, manganese (child only) and vanadium (child only) also contribute doses that each could exceed the corresponding reference dose values (i.e., HQ for each chemical exceeds 1E+00).

No HIs calculated for hypothetical future residential soil pathways exceed 1.0E+00 for adults. For hypothetical future child residents, HIs calculated for the soil pathway exceed 1.0 at Ponds 1 to 4 and the CRDA. At these exposure points nearly all potential risk is contributed by arsenic (HQ of 1E+00 in Ponds 1 through 4; HQ of 2E+00 in the CRDA). Antimony and vanadium in Ponds 1 to 4 each contribute HQs of nearly one. Since arsenic, vanadium and antimony all have different major critical effects it is appropriate to evaluate risk on a chemical by chemical basis. There does not appear to be concern for noncarcinogenic effects via the soil ingestion pathways at these locations except for arsenic at the CRDA.

6.4.3 Evaluation of Risks from Lead Exposure

Since there are no EPA-approved RfD values for lead, it is not possible to evaluate potential noncancer risks of lead by calculation of a Hazard Index. An alternative approach is to estimate the likely effect of lead exposure on the concentration of lead in the blood (PbB). Several mathematical models have been developed for calculating the value of PbB as a function of environmental

concentrations of lead. Of these, the Uptake/Biokinetic (UBK) model has the greatest flexibility and has been most thoroughly validated.

It is commonly agreed that young children are more susceptible to the effects of lead than older children or adults, since (1) young children tend to have higher exposure levels (especially to soil), (2) young children have higher lead absorption rates, and (3) the nervous system of infants and young children is more sensitive to the neurological effects of lead. The USEPA has developed a computer program ("LEAD4") for calculating lead exposures and the resulting PbB values in children. This program was used to evaluate the effects of lead in environmental media on children age 0 to 6 at this site. It should be noted that these calculations include lead exposure from all sources (including food and area-wide emissions to air), and not just those specifically derived from the site (soil and water). Most input parameters (e.g., body weight, water intake, soil intake, breathing rate, concentration of lead in air and lead intake from the diet) were taken to be the national average values suggested as defaults by the USEPA. The concentrations of lead in soil and water were the site-specific values calculated as assumed in Section 3.4.1 for current and hypothetical future residential scenarios.

Table 104 summarizes the results. Although there is no universally agreed upon value of PbB that may be identified as "safe" for the effects of lead on children, the USEPA has identified 10 to 15 μg/dL as a range of concern for health effects in children that warrant avoidance. As shown in Table 101, geometric blood lead values are predicted to range from 3.2 to 4.8 μg/dL for the various populations, and essentially no members of the exposed populations are expected to have values exceeding 15 μg/dL. On this basis, it appears that lead in surface soil or water is not a reason for significant concern.

6.4.4 Risk Summary

It is believed that at the Ormet site individuals from either current and hypothetical future populations may be exposed to contaminants of potential concern through several pathways. Total exposure equals the exposures by all pathways. However, potential risks are not routinely summed without giving considerations to the following:

- Identification of reasonable exposure pathway combinations

- Examination of whether the same individual could consistently face the reasonable maximum by more than one pathway

Potential risks should not be combined if two pathways do not affect the same population. Likewise, if the same population is not likely to face the reasonable maximum in each pathway, potential risks should be not combined.

At this site the following combinations are considered reasonable:

- A future maintenance worker might be exposed to both Pond 5 emissions and the contaminated groundwater (in a hypothetical no-pumping scenario)

- Hypothetical future residents would be reasonably expected to be exposed via all quantified pathways.

GERAGHTY & MILLER, INC.

Table 105 summarizes these potential risks estimated for exposures to carcinogenic contaminants. These values are presented such that total potential risk exclusive of the fish ingestion pathway is also included. It is recognized that the addition of all residential scenarios results in a carcinogenic risk summation that is likely to be greater than the reasonable maximum (as defined as the 95th percentile of the distribution). It is unlikely that any current or hypothetical future resident would consistently face a reasonable maximum exposure from every pathway quantified in this risk assessment.

6.5   Assessment of Uncertainties

There are many aspects of the risk assessment process where precisely accurate evaluation are not possible. There are a number of uncertainties inherent in modeling, exposure evaluation and toxicological information that must be acknowledged. The major sources of uncertainties in the risk estimates presented in this report include the following:

- Not all chemicals detected at the site were quantitatively evaluated in all conceivable exposure pathways. While this approach will underestimate risk, it is not likely to introduce significant error.

- A simplifying assumption that chemical concentrations detected during sampling will remain constant over a lifetime is likely to overestimate risk since there are on-going fate and degradation processes which will tend to reduce contamination over time.

- Numerous uncertainties exist in modeling of any kind. The emissions and air modeling performed for this site appear to be reasonable when compared to actual monitoring data at locations away from Pond 5. It is unknown whether actual PM_{10} concentrations at Proctor have been over or underestimated by the selected modeling approach.

- Determination of the appropriate exposure factors to use in calculation of human dose levels can be highly uncertain, especially when nonstandard exposure scenarios (e.g., the river scenarios) are evaluated. When faced with significant uncertainties in

selected appropriate values, an effort was made to use conservative, but not unrealistic values (i.e., protective of the individual who receives the reasonable maximum exposure). This is especially true of the fish ingestion and other river-related scenarios. Therefore, exposure calculations should be considered representative of above-average yet not worst-case estimates.
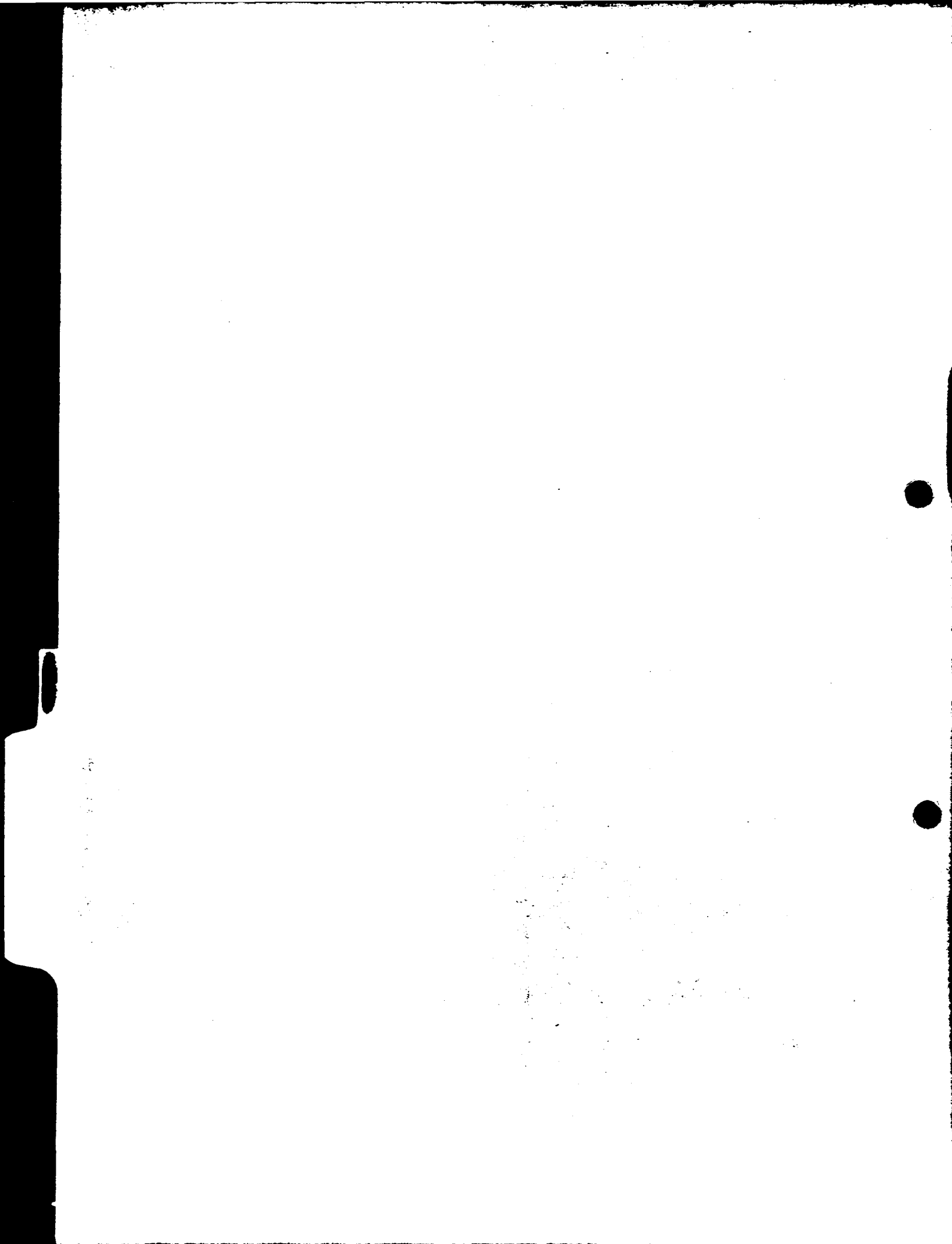
7.0   SUMMARY AND CONCLUSIONS

7.1   Summary

Data and findings presented in detail in sections 4.0, 5.0, and 6.0 of the RI report are summarized in this section. The summaries provided in this section address the following topics:

Nature and Extent of Contamination

Fate and Transport

Risk Assessment

7.1.1 Nature and Extent of Contamination

During the RI, investigative activities were conducted to evaluate the physical and chemical characteristics of potential source areas and other areas and media at the site that were potentially affected by the possible source areas. In this section, the findings and major interpretations from these investigations are summarized. Because this information is presented in detail in Section 4.0, discussions in this section will focus on the main parameters identified in water, soils, and sediments at the Ormet site.

The areas and media investigated during the RI and summarized in this section include:

- Former Disposal Ponds

- Former Spent Potliner Storage Area

- Carbon Runoff and Deposition Area

- Former Construction Material Scrap Dump

- Plant Recreation-Area Fill

- Ground Water

- Surface Water

- Sediments

- Air

- CAC Ranney Well

7.1.1.1   Former Disposal Ponds

At various times from 1958 to 1981, Ormet utilized one or more of the five retention ponds (Pond 1 through 5) located in the northeastern portion of the facility (see Figure 2). When in use, Ponds 1 through 4 received predominantly sludge from the former pot-room wet scrubbing system and may have also received some minor amount of treated tailings material from the cryolite recovery plant after it began operations in 1968. Pond 5 was put into service to receive treated tailings from the cryolite recovery plant, but may have also initially received minor amounts of sludge from the pot-room wet scrubber system.

Analyses of the composite sludge samples collected during the RI indicate that the materials in the ponds are typically composed of from 45 to 70 percent solids by weight. Overall, it appears that the moisture content of the pond sludges increases with depth.

Analytical data from the pond solids sampling program are provided in Tables 4 through 14. In general, the disposal pond sludges are characterized by an alkaline pH (i.e., pH greater than 7.0)

GERAGHTY & MILLER, INC.

and the presence of cyanide, fluoride, chloride, sulfate, a variety of metals, and PAHs. Only low concentrations (i.e., typically less than 0.1 mg/kg total and consistently less than 0.6 mg/kg total) of VOCS were detected in any of the pond solids samples. PCBs were not detected in any of the disposal pond solids samples. A summary of the metals detected in the disposal pond solids, as compared to concentrations reported in natural soils is provided in Table ES-1.

Based on water-quality data from monitoring wells surrounding and directly downgradient from the former disposal ponds, the pond-related contributions to the ground-water condition are much less significant than the effects caused by the former spent potliner storage area. With regard to impacts to ground water beneath Pond 5, historical data show that following its decommissioning, ground-water quality has showed substantial improvements (see Geraghty & Miller, 1982a, which is provided as an appendix to the Phase I RI Work Plan). Consequently, as long as the ponds remain inactive and relatively undisturbed, no increases in the downward movement of contaminants are expected.

There is also no evidence that surface-water runoff represents a direct pathway for migration of contaminants from the disposal ponds. The dike around each pond is intact and prevents stormwater from flowing from the pond surfaces to surrounding areas and media by surface-water runoff. As discussed further in Section 3.5.2, work conducted during the RI suggests that precipitation that infiltrates in the area of Pond 5 contributes to the discharge of the ballfield seeps and possibly the discharge of the steel conduit that extends from the berm of Pond 5.

The results of infiltrometer tests conducted during the RI indicate that the permeability of the pond surfaces ranges from slow (Ponds 1 and 2) to rapid (portions of Pond 5). The results of these

tests provide a characterization of the permeability of the uppermost portion of the pond solids and may have no correlation with infiltration velocities below the surface of the ponds. Consequently, the results of the infiltrometer tests cannot be used to predict the velocity of water or dissolved-constituent movement through the pond solids.

Based upon the results of the Phase I RI air monitoring program and the particle-size analyses performed on samples collected from the pond surfaces, the surface of Pond 5 represents a potential source for the release of wind-blown respirable dust.

Additional information regarding the physical and chemical characteristics of the individual ponds is discussed in the following paragraphs.

Ponds 1 and 2

Former disposal Ponds 1 and 2 are located immediately to the northeast of the main plant area, adjacent to the anode crushing mill (see Figure 2). Combined, Ponds 1 and 2 occupy around 2.5 acres and contain a total of approximately 14,500 cubic yards of sludge. Both of the ponds are underlain by sand and gravel deposits. Infiltration rates obtained for the surfaces of Ponds 1 and 2 are categorized as slow to moderate.

Analyses of sludge samples from Ponds 1 and 2 indicate that the material in these ponds is characterized by a higher pH (9.0 to 9.6) than the other ponds. The levels of cyanide amenable to chlorination were also higher than the other ponds. This may be related to a small amount of unneutralized cryolite plant tailings that was apparently placed on Ponds 1 and 2 when the cryolite

plant first began operations. The concentrations of fluoride and CLP total cyanide detected in samples from Ponds 1 and 2 were generally higher than Ponds 3 and 4, but lower than Pond 5. With regard to PAHs, the concentrations detected in Pond 1 and 2 were generally similar to those detected in Ponds 3 and 5.

Pond 3

Former disposal Pond 3 is located just to the east-northeast of Ponds 1 and 2 (Figure 2), occupies about one acre, and contains on the order of 13,500 cubic yards. Infiltration rates for Pond 3, which is underlain predominantly by sand and gravel, are categorized as moderate.

The pH values of sludge samples from Pond 3 (7.3 to 8.2) were lower than those for samples from Ponds 1, 2, and 5. Fluoride concentrations in Pond 3 were generally lower than the other ponds, except Pond 4. CLP total cyanide concentrations were also generally lower than the other ponds, with cyanide amenable to chlorination typically below detection. PAH concentrations in Pond 3 were lower than those reported for Pond 4, but generally in the same range as Ponds 1, 2, and 5. Samples from Pond 3 were higher than the other ponds in arsenic and chromium, and higher than all the ponds, except Pond 4, in calcium, iron, lead, nickel, and vanadium. The metals concentrations observed in the Pond 3 samples could be related to spent pickling liquor that may have been used to neutralize a small volume of cryolite plant tailings that was reportedly placed on Pond 3.

Pond 4

Former disposal Pond 4 is a roughly triangular-shaped pond that occupies about one acre immediately north of Pond 3. The volume of sludge contained in Pond 4 is estimated to be around 17,800 cubic yards. Pond 4 is underlain by sand and gravel. Infiltration rates for the surface of Pond 4 are categorized as moderate.

The samples collected from Pond 4 exhibited the lowest pH (7.1 to 7.2) of all the former disposal ponds and were also lower in fluoride than the other ponds, except Pond 3. Concentrations of CLP total cyanide in Pond 4 were similar to those detected in Ponds 1, 2, and 3, but were generally lower than Pond 5. However, the levels of cyanide amenable to chlorination detected in Section A of Pond 4 were similar to those detected in Ponds 1 and 2 and were higher than in Pond 3, Pond 5, and Section B of Pond 4. The samples from Pond 4 also had higher concentrations of PAH than samples from the other ponds. Similar to Pond 3, samples from Pond 4 were generally higher in several metals than samples from Ponds 1, 2, and 5, including calcium, chromium, copper, iron, lead, nickel, and vanadium. The higher metals concentrations observed in the samples from Pond 4 could be related to spent pickling liquors which may have been applied to Pond 4 to neutralize cryolite plant tailings that may have been placed on Pond 4 when the cryolite plant began operations.

Pond 5

Former disposal Pond 5 is located just to the east of Ponds 3 and 4 and adjacent to the southeast edge of the former spent potliner storage area. Pond 5 covers approximately 12 acres and contains on the order of 370,000 cubic yards of sludge. Approximately the southeastern one half of

Pond 5 is underlain by low permeability silt and clay and the northwestern one half is underlain by sand and gravel. Infiltration rates obtained for the surface of Pond 5 are categorized as moderate to rapid.

Because Pond 5 received the treated tailings from the cryolite recovery plant, whereas the other ponds received sludges mainly from an air emissions wet scrubbing system, the analytical results for the pond solids samples from Pond 5 exhibit several differences compared to the other ponds. In particular, Pond 5 is generally higher in total cyanide and aluminum than the other ponds. This is because Pond 5 received predominantly treated tailings from the cryolite plant, which processed spent potliner, and the other ponds received little or no cryolite plant tailings. In addition, the concentrations of chloride detected in Pond 5 samples were higher than in the other ponds and cyanide amendable to chlorination was generally below detection. This reflects the chlorination step in the cryolite plant process, which was intended to destroy free and simple cyanides. Overall, the total PAH concentrations in Pond 5 were similar to the levels in Ponds 1, 2, and 3, but lower than Pond 4.

7.1.1.2   Former Spent Potliner Storage Area (FSPSA)

The FSPSA occupies about 13.8 acres in the northeastern portion of the Ormet property (see Figure 2). It is bordered to the southeast by former disposal Pond 5, and may in the past have extended beneath the current northwestern berm area of Pond 5. During its former active use (approximately 1959 to 1968), spent potliner material was stockpiled in the FSPSA prior to subsequent recycling by the Ormet cryolite recovery plant. Beginning in November, 1980, the remaining spent potliner in this area was transported off-site for disposal. Since the shutdown of the cryolite-recovery plant in the fall of 1981, all spent potliner has been transported off-site for disposal.

Soils affected by the FSPSA are characterized by a pH ranging from around 8.0 to 10.7 and concentrations of total cyanide (up to 2043 mg/kg), fluoride (up to 1648 mg/kg), and sodium (up to 83,750 mg/kg), which are regarded to be indicator parameters for FSPSA-related effects. Isopleth maps showing the relative concentrations of these parameters within the upper 10 feet of soils beneath the FSPSA are provided in Figures 49 through 73.

Other constituents detected in soils beneath the FSPSA at variable concentrations include PAHs (up to 7067 mg/kg total), arsenic (up to 25 mg/kg), and aluminum (up to 42,500 mg/kg). Soil quality data for the FSPSA are presented in Tables 16 through 21 and a more detailed discussion of the soil conditions is provided in Section 4.1.2. A summary of the metals detected in the FSPA soils, as compared to concentrations reported in natural soils is provided in Table ES-1.

Leaching of the soils beneath the FSPSA has affected ground-water quality beneath and hydraulically downgradient from the FSPSA. These effects to ground water quality are most evident by the elevated pH, ranging from around 8.0 up to 10.5, and above background concentrations of total cyanide (up to 18.2 mg/L total CLP), fluoride (up to 1000 mg/L), and sodium (up to 2640 mg/L). These parameters are regarded as indicators of ground-water quality impacts related to the FSPSA, and are graphically plotted to create the plume isopleth maps presented in Figures 108 through 111.

As shown in Figures 108 through 111, affected ground water beneath and downgradient from the FSPSA exists as an elongated and relatively narrow plume that extends from the FSPSA toward the Ormet interceptor wells. Through pumping of either interceptor well #1 or #2 along with drawdown caused by the Ormet Ranney well, affected ground water at the site is being contained. The discharge of ground water pumped from interceptor wells #1 or #2 through the Ormet NPDES

004 outfall and the effects that this discharge may have on other environmental media is discussed in
Section 7.1.1.6.

Other parameters identified in the ground water that appear to be related to leaching of soils
within the FSPSA are aluminum (up to 178 mg/L), TOC (up to 280 mg/L), silica (up to 4300 mg/L:),
iron (up to 144 mg/L), arsenic (up to 0.394 mg/L), chromium (up to 0.401 mg/L), cobalt (up to 0.814
mg/L), copper (up to 1.02 mg/L), nickel (up to 0.767 mg/L), and vanadium (up to 0.369 mg/L). Of
these, aluminum and silica are attributed to the high-pH condition of the affected soils and water
beneath the FSPSA, due to the increase in solubility that these parameters undergo in response to
elevated pH.   Under the basic pH conditions characterizing ground water beneath the FSPSA,
dissolved aluminum exists as $Al(OH_4^-)$, and silica exists as dissociated silica acid ($H_3SiO_4^-$). TOC
concentrations also show a relationship to the pH of the ground water beneath the site.   Iron
concentrations in ground water beneath the FSPSA are thought to reflect the presence of iron-cyanide
complexes, an interpretation that is supported by the occurrence of high total cyanide in ground-water
samples containing high iron concentrations. The relationship that ground-water concentrations of
arsenic, chromium, copper, cobalt, nickel, and vanadium may have to the FSPSA is less certain, but
may reflect the fact that coal-derived materials are part of the make-up material for spent potliner,
and most or all of these metals can be naturally present in coal at elevated levels.

A potential also exists for the FSPSA to affect air quality. This is because the FSPSA is
sparsely vegetated. Consequently, a potential exists for the erosion and transport of surface soils by
the air.

7.1.1.3 Carbon Runoff and Deposition Area (CRDA)

The CRDA is described as the wooded area of the plant site bounded on the west by the toe of the slope below the plant fence line between wells MW-3 and MW-40, on the east by the toe of the CMSD, on the north by the fence line south of Ponds 1 and 2, and on the south by the Ohio River (see Figure 2). The carbon deposits in this area cover approximately 3 acres and vary in depth up to about 5 feet deep. The total volume of carbon material present in this area is estimated to be on the order of 5,700 cubic yards.

The topography of the CRDA is relatively flat, with much of the area covered by grasses and trees. Two localized portions of the CRDA are devoid of vegetation and are subject to erosion and are within the 100-year flood plain. Although the area is relative flat, it is subject to surface-water runoff and the carbonaceous material in the CRDA is similar to the carbonaceous material in the 004 backwater area.

The results of laboratory analyses of samples of the carbon material and underlying soil collected during the RI by Geraghty & Miller are provided in Tables 33 through 41. These analyses detected low concentration (typically less than 0.035 mg/kg and consistently less than 0.35 mg/kg) of several VOCs and did not detect PCBs. Analysis of a single composite sample of carbon material obtained by the USEPA Environmental Response Team during their ecological survey detected Arochlor 1248 at 56 mg/kg. Concentrations of total PAHs were higher in the carbon material (15.151 mg/kg to 149.6 mg/kg), than in the underlying soil (up to 9.033 mg/kg), with the concentrations reported in the soil interpreted to be within the background range for natural soils. With regard to metals, the concentrations detected in the carbon material were typically higher than in the underlying

soil. Four metals, barium, iron, manganese, zinc, were commonly detected at higher concentrations in the soil samples than in the overlying carbon material. A summary of the metals detected in the carbon samples from the CRDA, as compared to concentrations reported in natural soils, is provided in Table ES-1. Concentrations of CLP total cyanide were higher in the carbon material (13 to 254 mg/kg) than in the soil (1.0 to 25 mg/kg), with cyanide amenable to chlorination typically below detection in the soils.

As evidenced by the low concentrations of parameters such as PAHs, metals, and cyanide in the soils, relative to the levels of these parameters that were detected in the overlying carbon, vertical migration of constituents in the carbon deposits has been limited by the low permeability soils that underlie the area. Consequently, the CRDA does not contribute to the plume in the alluvial aquifer. The CRDA is underlain by predominantly silt and/or clay deposits that are characterized by a vertical permeability typically in the 10^{-7} to 10^{-8} cm/sec range.

Due to the relatively flat topography of the area and the thick covering of grasses and trees, surface-water runoff and air emissions are not considered to be important pathways for constituent migration from the CRDA. Although, some migration of constituents from the CRDA by surface-water runoff may have occurred prior to the growth of the existing vegetation.

7.1.1.4   Construction Material Scrap Dump (CMSD)

The CMSD is located adjacent to the Ohio River and abuts the southern and southwestern berms of Pond 5 (see Figure 2). The CMSD covers about 6.2 acres, and was used from about 1966 to mid-1979. Based on information from the installation of monitoring well MW-13, which penetrates

the CMSD materials, and visual observation of the exposed face of the CMSD, the CMSD materials may be on the order of 25 or more feet thick in some areas. Four test pits were excavated in the CMSD to visually inspect its contents and to collect samples from the dump materials for laboratory analysis (see Figure 75 for the test pit locations and Tables 27 through 32 for analytical results).

Laboratory analyses of composite samples collected from the test pits detected a variety of organic and inorganic constituents, which are the result of the assorted nature of the materials present in the CMSD. Several VOCs were detected in the CMSD samples, but at low concentrations (from below detection to 0.043 mg/kg). The only semi-volatile organics detected in the CMSD test pit samples were PAHs. Total PAH concentrations in the CMSD samples ranged from 297.06 mg/kg to 1981.5 mg/kg. The PCB Aroclor 1248 was detected in each of the CMSD solids samples, at concentrations from 3.632 to 22.6 mg/kg. Analyses of a grab sample of the oil/water emulsion that was encountered in Pit #2 also detected Aroclor 1248 at 0.725 mg/L.

With regard to metals, 18 of the 23 metals on the USEPA Target Analyte List were detected in the CMSD composite samples. Antimony, mercury, selenium, silver, and thallium were not detected in any of the samples. The detection of a variety of metals in the CMSD samples is probably due to the assorted nature of the materials in the CMSD and the acid-extraction type analysis that is run under the CLP program. A summary of the metals detected in the CMSD samples, as compared at concentrations reported in natural soils, is provided in Table ES-1.

Total cyanide concentrations in the sample from the CMSD ranged from 7.90 to 21.7 mg/kg and cyanide amenable to chlorination was below detection. Fluoride levels in the samples were from

44 to 540 mg/kg, probably reflecting the presence of cryolite material, which was commonly observed in the test pits.

Surface-water runoff, via the seeps that discharge at the base of the CMSD, is a potential pathway for migration of constituents from the CMSD. The seeps which emanate from the base of the CMSD are probably fed, at least in part, by precipitation which infiltrates through the materials in the CMSD. At the base of the CMSD, the water encounters the low-permeability silt and clay layer, which underlies the entire dump, and then flows laterally to the seep discharge points. Because the CMSD is entirely underlain by low permeability silt and clay, the potential for impacts to ground water in the alluvial aquifer related to the CMSD is considered to be very low. Water that discharges from the CMSD seeps flows overland a short distance to the 004 outfall stream. Analytical data from samples that were collected from the seeps during Phase I and Phase II are included in Tables 22 through 26.

Water discharging from the seeps at the base of the CMSD is characterized by concentrations of the primary inorganic indicator parameters for the Ormet site, including total cyanide and fluoride. The CLP total cyanide concentration reported in the CMSD seep samples ranged from 0.163 mg/L to 0.950 mg/L. Cyanide amenable to chlorination was from below detection to 0.549 mg/L. Fluoride levels in the CMSD seep samples were from 62 mg/L to 160 mg/L.

The analytical data for the CMSD seeps indicate only minor concentrations of volatile and semi-volatile organic compounds. With the exception of acetone (0.033 mg/L to 0.049 mg/L), the only VOC that was detected in the CMSD seep samples was 1,1,1-trichloroethane (0.005 mg/L to 0.015 mg/L). The only semi-volatile compound reported at above the CRDL in the seep samples was bis

(2-ethylhexyl)phthalate (0.016 mg/L). Also reported in Seep #2 and Seep #3 at the base of the CMSD was Aroclor 1242. Reported concentrations ranged from 0.00083 mg/L to 0.0074 mg/L. Aroclor 1242 was also detected in surface water samples from the 004 backwater area and the Ohio River immediately downstream of the backwater area. The occurrence of Aroclor 1242 in surface water samples is discussed further in Section 7.1.1.7.

7.1.1.5   Plant Recreation Area Fill

Tasks were performed during the RI to investigate the nature and extent of an area of debris (construction rubble) located on the slope leading down to the Ormet baseball field. Soil borings that were drilled adjacent to the area of debris did not encounter rubble material, indicating that the occurrence of the debris is limited to the face of the slope.

Analytical data for Seep #1 and Seep #4, which are located along the base of the slope near the ballfield (see Figure 78), are provided in Tables 22 through 26. These seeps are interpreted to represent, at least in part, discharge from a localized perched ground-water zone that exists beneath the northeastern edge of Pond 5. This perched zone is believed to be recharged by infiltration that precipitates through the pond sludge materials and accumulates in layers of fill material beneath the pond dike.

The analytical data for the ballfield seeps indicate the presence of the primary inorganic indicator parameters in the seep water, including total cyanide, fluoride, sodium, and pH. Total cyanide concentrations in the seeps ranged from 0.0794 mg/L to 0.733 mg/L, with cyanide amenable to chlorination up to 0.0686 mg/L. Fluoride and sodium concentrations were from 6.5 to 92 mg/L and

from 945 to 3520 mg/L, respectively. The pH of the ballfield seeps was up to 8.6. PCBs were not detected in the ballfield seeps.

7.1.1.6   Ground Water

Ground-water flow and water-quality obtained during the RI indicate the presence of a plume in the alluvial aquifer that emanates mainly from the vicinity of the former spent potliner storage area. This plume is characterized by a basic pH, ranging from 8.0 to 10.5, and above background concentrations of total cyanide, fluoride, sodium. The above-background concentration trends for these indicator parameters for the plume are graphically illustrated by the plume isopleth maps presented in Figures 108 through 111, and are tabulated in Tables 66, 76, and 77. With regard to total cyanide, the reported concentrations reflect the combined concentrations of the relatively-stable cyanide complexes (e.g., iron cyanide Fe_n CN), and free or simple cyanides, such as CN^- and weak cyanide complexes, which are less stable and thereby "amenable to chlorination".

From the area of origin, the plume moves with ground-water flow through a section of aquifer about 3000 feet in length toward interceptor wells #1 or #2 and the Ormet Ranney well. By this flow condition, the plume body exhibits an elongate shape, with highest concentrations in the vicinity of the former spent potliner storage area (see Figures 108, 109, and 111). As the plume is pulled through the aquifer toward the Ormet Ranney well and interceptor wells, concentrations decrease with distance from the source area. This trend is attributed mainly to mixing (dilution) and possibly attenuation within the alluvial aquifer system.

Ground-water withdrawals by the Ormet and CAC Ranney wells have created two large cones of influence, one around each pumping center, which converge to form a gently rounded ground-water divide that is situated roughly parallel and to the south of Ormet's southwest property boundary. By this condition, the plume in the alluvial aquifer is contained beneath the Ormet property, and under current pumping conditions a hydraulic potential does not exist for ground water beneath the Ormet plant to flow toward the CAC Ranney well.

Certain metals appear to exhibit some relationship to the plume in the alluvial aquifer, including lead (two wells over 0.05 mg/L), aluminum (up to 178 mg/L), arsenic (up to 0.394 mg/L), chromium (up to 0.401 mg/L), cobalt (up to 0.814 mg/L), copper (up to 1.02 mg/L), nickel (up to 0.767 mg/L), beryllium (up to 0.035 mg/L), and vanadium (up to 0.369 mg/L). The occurrence of these metals in association with the plume is believed to be related to anthracite coal, which is a major component of potliner material. Analyses for non-CLP constituents characterizing general-water quality indicate several alterations associated with the above-neutral pH condition. Introduction of a high-pH plume to an aquifer system that naturally exhibits a near-neutral pH causes natural buffering mechanisms to engage. These effects are thought to be evident in the concentration trends observed for dissolved silica and TOC, which show generally increasing concentrations relative to increasing pH. The interpretation is that weak natural acids (silicic and humic/fulvic) dissociate in response to the above-neutral pH condition, liberating hydrogen ions to buffer the caustic condition. As a result, ionized species of silica ($H_3SiO_4^-$) and TOC-contributors are produced. The sand and gravel deposits of the alluvial aquifer provide virtually unlimited silica, and thin layers of peat and/or weathered coal present within the aquifer matrix provide a source of natural organic material. The dissolution of natural organic material is thought to contribute to the tea- to coffee-color appearance of ground-water sampled from the high-pH plume.

Aluminum concentrations are also attributed to the basic pH condition. At a pH greater than 8, aluminum is dissolved from the soils and aquifer materials and can exist as Al(OH)$_4^-$, which increases its solubility.

With regard to organic compounds, PCBs were not detected in any of the ground-water samples. The only VOC that was reported at levels above the CRDL was tetrachloroethene. Tetrachloroethene was detected in samples from five monitoring wells, at concentrations ranging from 0.005 mg/L to 0.040 mg/L.

PAHs were not detected above the CLP CRDL in any of the ground-water samples analyzed. In accordance with Task 5.C. of the SOW, ground-water samples from selected monitoring wells (MW-2, MW-14, MW-19, MW-31, MW-35, and MW-37) were analyzed for certain PAH compounds using a special analytical procedure (developed by Ormet at the direction of USEPA and OEPA) with a 20 ng/L (parts per trillion) detection limit. The PAH compounds analyzed are the following: naphthalene, benzo(a)anthracene, chrysene, benzo(k)fluoranthene, and benzo(a)pyrene. Naphthalene results ranged from below detection to 60 ng/L, with the highest concentration reported for the field blank sample. Chrysene and benzo(k) fluoranthene were reported in three of the samples (MW-2, MW-31, and MW-37) at concentration ranging from 28 ng/L and 25 ng/L to 44 ng/L, respectively. Benzo(a) anthracene and benzo(a) pyrene were reported in only one sample (MW-2 and its duplicate) at concentrations up to 32 ng/L and 35 ng/L, respectively. None of the selected PAH compounds were reported above 20 ng/L in the MW-19 background monitoring well.

7.1.1.7   Surface Water

Data obtained during the RI indicate that CLP volatile and semi-volatile organic compounds, including PAHs, are generally below the CLP CRDL detection limit in the surface water. The only volatile organics reported were methylene chloride and acetone, which were reported in nearly all of the samples at values ranging from 0.001 to 0.002 mg/L and 0.008 to 0.020 mg/L, respectively.

Three semi-volatile organics, fluoranthene, pyrene, and chrysene were reported in the sample from the backwater (SW-5), each below the CLP detection limit at an estimated concentration of 0.003 mg/L. As described in Section 2.4, surface-water samples collected from the Ohio River at three locations upriver from the Ormet site were analyzed for selected PAHs using a special analytical procedure (developed by Ormet at the direction of USEPA and OEPA) with a detection limit of 20 ng/L. As shown in Table 56A, these analyses detected each of the PAH compounds that was being analyzed for, including naphthalene (29 ng/L to 140 ng/L), benzo(a) anthracene (48 ng/L to 3000 ng/L), chrysene (85 ng/L to 2900 ng/L), benzo (k) fluoranthene (38 ng/L to 1200 ng/L), and benzo (a) pyrene (at 3800 ng/L).

PCB Arochlor 1242 was reported in the SW-5 backwater sample, and the SW-9 sample immediately downstream from the backwater area (see Figure 81). The reported concentrations were 0.0015 and 0.0010 mg/L, respectively. The Aroclor 1242 detected at SW-5 and SW-9 is attributed to an oily film observed with the discharge from Seep #2 at the southwest toe of the construction material scrap dump. Samples from Seep #2 were reported to contain Aroclor 1242. Section 4.1.4 summarizes the data obtained from the seep-sampling program.

Analysis of surface-water samples collected within and downstream of the backwater area (i.e., SW-5, SW-9, and the more downstream SW-12 locale) indicate water-quality characteristics attributable to certain on-site sources and to the contaminated ground water discharged through the NPDES-permitted outfall 004. These effects are evident mainly by above-background pH and concentrations of sodium, fluoride, and total cyanide. The highest values for pH (8.5), sodium (162 mg/L), and fluoride (12 mg/L) were reported for the SW-5 sample, which was taken from within the backwater area of the outfall discharge. With distance downstream from the backwater area, these parameters show a steady decrease to pH = 8.04, sodium = 52 mg/L, and fluoride = 3.3 mg/L at SW-9. At the SW-12 location, the concentrations of fluoride (0.3 mg/L) and sodium (12.3 mg/L), and the pH (7.8) approach the background levels indicated in SW-1. The pattern of reported total cyanide concentrations is somewhat anamolous, in that, reported values are higher in the SW-9 sample (0.428 mg/L), immediately downstream of the backwater area, than in the SW-5 sample (0.125 mg/L) collected from within the backwater. In the SW-12 sample taken furthest downstream, total cyanide was reported at 0.0076 mg/L.

Of the CLP metals, data from SW-5 and SW-9 show some increases (relative to background) for dissolved arsenic (0.010 mg/L in SW-5 only), total (unfiltered) chromium (0.012 mg/L and 0.010 mg/L), total copper (0.026 mg/L and 0.016 mg/L), dissolved iron (0.812 mg/L and 0.357 mg/L), and dissolved manganese (0.726 mg/L and 0.349 mg/L).

As discussed in more detail in Section 3.5.1, the operation of the Ormet Ranney well maintains water levels in the alluvial aquifer that are below the river pool elevation. As a result, the primary source of recharge to the alluvial aquifer is water that is drawn from the river into the aquifer.

Considering this hydraulic relationship, the potential exists for the Ohio River to contribute to the quality of water in the alluvial aquifer (see Section 4.2).

7.1.1.8   Sediments

Outfall 004 Backwater Sediments

The outfall 004 backwater area is situated immediately to the southwest of the construction material scrap dump, and exists as muddy shoal that extends southward to the Ohio River. The NPDES 004 outfall stream flows through the backwater area in route to the Ohio River (see Figure 81).

Backwater sediments (as characterized by Phase I and Phase II samples from the RS-5 location or its duplicate sample analyses) reported total PAH concentrations ranging from 1122 to 1635 mg/kg and PCB Aroclor 1248 at 97.5 mg/kg; see Tables 48, 49 and 50 and Figure 83. The general indicator parameters detected at above background concentrations in the RS-5 backwater sediment samples are fluoride (up to 109 mg/kg), total CLP cyanide (42 mg/kg), and sodium (2060 mg/kg); see Tables 45 and 46 and Figure 82. CLP metals showing a possible relationship to the RS-5 sample location include calcium (32,500 mg/kg), magnesium (6,120 mg/kg), and copper (119 mg/kg); see Table 45 and Figures 84, 85, and 86).

With the exception of methylene chloride and acetone (both at 0.032 mg/kg), no volatile organic compounds or semi-volatile organic compounds, other than PAHs, were reported above the CRDL in the RS-5 sediment samples.

Ohio River Sediments

Ohio River sediment samples were collected along the shore line of the river, adjacent to the Ormet site during both Phase I and Phase II. These included background samples (RS-1 series), samples from locations upstream from the backwater area but downstream from RS-1 (RS-2, RS-3, and RS-4 series), and samples from locations at the mouth of the backwater (RS-6) and downstream from this point (RS-7, RS-9, RS-12).

River sediment constituents that appear to show a relationship to the backwater area include the following:

•   Total PAHs, ranging from 26 to 176 mg/kg at RS-6 (at the month of the backwater), and dropping to 7 to 32 mg/kg at the downstream locations RS-9 and RS-12 (Table 50 and Figure 83);

•   PCB Aroclor 1248 reported at 2.2 mg/kg at RS-6, 1.1 to 1.3 mg/kg at RS-9, and 1.0 to 2.5 mg/kg at RS-12 (Table 48 and Figure 83); and

•   Fluoride and total CLP cyanide reported at RS-6 at 27 mg/kg and 1.6 mg/kg, respectively (Table 45 and 46 and Figure 82).

In river sediment samples RS-2 through RS-4, collected upstream of the backwater area and downstream of the background RS-1 location, total PAHs ranged from 7.7 to 25.6 mg/kg and PCB

Aroclor 1248 was consistently below detection (Table 48, 49, and 50 and Figure 83). The river

sediment data give some indication that higher values reported for barium, chromium, cobalt, copper,

iron, lead, manganese, mercury, zinc, and nickel may tend to occur in the RS-2, RS-3, and/or RS-4

samples (see Tables 45 and Figures 84, 85, and 86).

With the exception of the reported detections of dimethylphthalate in RS-6 (0.52 mg/kg), 2-

butanone in RS-3 (0.120 mg/kg), benzene in RS-2 (0.024 mg/kg), and methylene chloride in RS-1,

RS-2, and RS-6 (0.037 to 0.049 mg/kg), no volatile organic compounds or semi-volatile organic

compounds other than PAHs were reported above the CRDL in the Ohio River sediment samples.

7.1.1.9   Air

Air

Based on physical characteristics and particle size distribution data, Pond 5 was identified as

the only area at the Ormet site where wind erosion could result in fugitive emissions of respirable dust

(i.e., particulate matter less than 10 μm in diameter - PM_{10}). To quantify the airborne transport of

respirable dust from Pond 5, a modeling approach was utilized that takes into account a calculated

wind-speed dependent emission rate. These emission rates and site-specific meteorological data were

used to model PM_{10} concentrations that were measured at on-site air monitoring stations. The results

of the air monitoring and air modeling tasks are provided in the Baseline Risk Assessment, which is

included in Appendix R.

7.1.1.10   CAC Ranney Well

Sampling of the CAC Ranney well (see Figure 1) was conducted on June 22, 1990 and again on July 20, 1990. The samples for ground-water analyses were collected at the wellhead, before the water has passed any of the treatment steps applied by CAC. The samples for drinking water analyses were collected from a point in the main distribution line immediately after CAC's treatment system, which includes chlorination. The analytical results for the ground-water and drinking water samples are provided in Tables 79 through 86. Provided in the following sections are summaries of the results of the ground-water and drinking water data.

CAC Ranney Well (Ground Water)

Two VOCs were reported in the ground-water samples and their field duplicates at concentrations above the CRDL (see Table 79), methylene chloride (0.005 mg/L to 0.014 mg/L) and acetone (0.039 mg/L and 0.043 mg/L. Four other VOCs were reported in the CAC Ranney well samples at concentrations at or below the CRDL, including 1,1-dichloroethane (0.001 mg/L), chloroform (0.002 mg/L to 0.005 mg/L), 2-butanone (0.002 mg/L), and 1,1,1-trichloroethane (0.002 mg/L).

No semi-volatile organic compounds, pesticides, or PCBs were detected in any of the CAC Ranney well ground-water samples (see Tables 80 and 81).

With regard to the main plume indicators for the Ormet site, the pH values for the CAC Ranney well samples were very consistent and near neutral (i.e., 7.2 to 7.3). Total cyanide and cyanide

amenable to chlorination were not detected in any of the samples. Fluoride concentrations (0.3 to 0.8 mg/L) and sodium concentrations (18.8 mg/L to 20.3 mg/L) were within the normal range for the alluvial aquifer. By these data, there is no indication of any alternations to the water quality at the CAC Ranney well related to conditions at the Ormet site. These data are also consistent with the interpretation of ground-water flow in the alluvial aquifer (see Section 3.5.1 and Figures 112 and 113), which indicate that a hydraulic potential does not exist for ground water beneath the Ormet plant to flow toward the CAC Ranney well.

CAC Ranney Well (Drinking Water)

Of the inorganic drinking water parameters analyzed on the samples from the CAC Ranney well (see Table 84), only manganese was detected at concentrations (1.3 to 1.4 mg/L) above an existing drinking water standard (manganese has a secondary drinking water standard of 0.05 mg/L).

Five VOCs were detected in the drinking water samples from the CAC Ranney well (see Table 86), including 1,1,1-trichloroethane (0.002 mg/L to 0.00253 mg/L), cis-1,2-dichloroethene (0.0207 mg/L to 0.0228 mg/L), chloroform (0.00082 mg/L and 0.00096 mg/L), dichloromethane (0.00514 mg/L), and 1,1-dichloroethane (0.0012 mg/L to 0.00145 mg/L). Three VOCs, o-, m-, and p-dichlorobenzene, were detected in the field blank samples (concentrations from 0.0012 mg/L to 0.00497 mg/L) during both the June and July sampling events, but were not detected in the actual drinking water samples, indicating that these compounds are not associated with the CAC Ranney well.

The data generated during the RI indicate that the drinking water quality at the CAC Ranney is not being affected by conditions at the Ormet site.

Ormet Ranney Well

Sampling of the Ormet Ranney well (see Figure 1) was conducted during the Phase II RI, on February 23, 1990. A sample and a field duplicate were collected from a valve at the wellhead. The pH values of the ground water samples from the Ormet Ranney well were near-neutral, ranging from 7. 5 to 7.6. Of the other primary indicators of ground-water impacts at the Ormet site, fluoride was detected at 1.3 mg/L and 37 mg/L; iron was reported at 0.1 mg/L in both samples; and CLP total cyanide concentrations were 0.0806 mg/L and 0.158 mg/L.

7.1.2 Transport and Fate

To evaluate fate and transport of a constituent, the chemical and physical properties of the constituent and the surrounding environment are evaluated. The fate and transport of constituents varies based on degree of persistence, physical, and chemical properties, such as solubility and volatility, and whether the compound can be degraded naturally or only under induced conditions.

The polycyclic aromatic hydrocarbons (PAHs) detected at the site generally sorb strongly onto soil, carbon material, and suspended particulates which limits mobility. Biodegradation and biotransformation are the ultimate fate process in soils and sediment. PAHs will undergo photolysis upon release to surface water. Bioconcentration of PAHs in aquatic organisms occurs; however, it is not a long-term situation in most aquatic organisms as PAHs are rapidly metabolized and excreted.

The BCF values reported for the PAHs detected at the site range from 10.5 to 1,150. Some species of invertebrates (e.g., bivalve mollusks) can bioaccumulate PAHs. Volatilization from soils and surface water is the major removal mechanisms for the monocyclic aromatic hydrocarbons (MAHs) and oxidation in the atmosphere destroys the constituents. The MAHs detected exhibit moderate to high mobility in soil and extensive biotransformation (measured as loss of parent compound) has been reported in soils. In general, the chlorinated aliphatic hydrocarbons have high aqueous solubilities and vapor pressures, low soil sorption, and slow hydrolysis rates. Volatilization from surficial soils and surface water is to the atmosphere where rapid decomposition occurs.

All of the inorganic compounds detected at the site are naturally-occurring in conterminous U.S. soils. Redox potential (Eh) and acidity/basicity (pH) control metal speciation (the form of the molecule or ion in solution) and affect the degree to which the following mechanisms (adsorption by soil; precipitation or coprecipitation; adsorption to iron, aluminum, and manganese oxides; and complexation with organic matter and ion exchange) attenuate metals.

Antimony sorbs to clay and minerals which results in the removal of antimony from solution and reduces its aqueous transport. A reported BCF of 1 indicates bioaccumulation is insignificant.

Arsenic occurs in 4 valence states which are affected by pH and Eh. In surface water, arsenic is very mobile and sediments serve as a reservoir. Sediment-bound arsenic may be methylated by microorganisms and released in the water column. Methylated arsenic is less toxic than inorganic arsenic. Most animals and humans metabolically convert inorganic arsenic (III) to monomethyl arsenic and dimethyl arsenic, with a decrease in toxicity corresponding to one order of magnitude for each

added methyl group. A BCF of 44 indicates bioconcentration occurs but biomagnification is not significant.

Barium is a reactive metal which exists as a number of salts in the environment. Barium ions are rapidly precipitated or removed from solution in natural waters by adsorption to sulfate and carbonate and sedimentation as a insoluble, non-toxic compound. Available information suggests that barium is not bioaccumulated in aquatic orgisms. The BCFs for fish and shellfish are reported as 4 and 0.2, respectively.

Beryllium, a trace element, has low solubility and, as a result, only low concentrations are expected to be in ground water. At low pH, beryllium adsorbs onto clay. Beryllium may be accumulated to a slight extent (BCF of 19) by aquatic organisms.

Chromium exists in soil and water in a trivalent or hexavalent oxidation state depending on the presence of oxidizing or reducing agents. Hexavalent chromium reacts with reducing agents to form the less toxic trivalent chromium. Dominant fate processes for trivalent chromium include reaction with aqueous hydroxide ions to form an insoluble precipitate and adsorption of dissolved chromium to soils. A BCF of 16 in freshwater fish was reported for chromium. Chromium is also accumulated to a greater extent in algal and salt water organisms.

Copper, naturally-occurring in soils, exists in two oxidation states: cuprous and cupric. In aerated waters with a pH of 6 to 8, cuprous copper oxidizes to the cupric state. The presence of organic acids and acidic conditions may lead to the mobilization of copper from soils/sediments to

solution, however, copper exhibits a strong affinity to sorb to organic matter and clays which limits mobility. The BCF for copper in freshwater fish is relatively low, with a reported value of 36.

Lead is present in soils of the conterminous U.S. and anthropogenic sources have contributed significantly to background levels over the past several decades. Municipal waste incineration and primary lead smelting are the current major sources of lead emissions. Organolead compounds are volatile and exist in the vapor phase; however, they rapidly decompose and are removed from the atmosphere. Lead forms insoluble compounds with naturally-occurring anions in surface water and can complex with organic matter or be adsorbed by soils. Shellfish , aquatic plants, and some invertebrates may accumulate lead, but bioaccumulation in edible tissue of fish is likely to be insignificant. The reported BCF for fish is 42.

Manganese is widely distributed in sediments, soils, and plant material (it participates in plant metabolism). Manganese is detectable in minor amounts in most ground water. Data regarding manganese bioaccumulation are not available.

In nature, mercury strongly sorbs to many surfaces and a major portion has been found associated with particulates which may be transported by sediment mobilization. Mercury can enter the atmosphere via volatilization with organomercury, which is more volatile than divalent mercury. BCFs for freshwater fish are reported to range from 1,000 to 5,500 for mercury. Methyl mercury is the form of mercury present in most fish tissue. Methyl mercury is readily accumulated by fish both from their food and through water.

Nickel is a naturally-occurring metal that is found in all parts of the environment. In natural waters, absorptions is moderately effective in limiting mobility, and under reducing conditions an insoluble sulfide can be formed.

Zinc can occur in both dissolved and precipitated forms in the environment. Sorption of the divalent zinc cation by clays and/or organic matter is the predominant fate in aerobic soils and water. Precipitation as zinc sulfide limits mobility in anaerobic environments. A BCF of 47 has been reported; however, biomagnification is not believed to occur.

The fate and transport of cyanide in environmental media is dependent on the physical and chemical properties of the inorganic or organic compound that contains the cyanide ion. Depending upon the type of cyanide present, fate processes such as biodegradation and volatilization may occur. Bioconcentration and bioaccumulation of cyanide is not expected. The reported fish BCF is 1.0.

Carbon disulfide is relatively mobile in soils, volatilization and photooxidation are primary fate processes, and bioaccumulation is not expected to be significant.

Sorption and biodegradation are the primary fate and transport mechanisms affecting bis(2-ethylhexyl)phthalate. Volatilization is low and biodegradation is rapid under aerobic conditions. Bioconcentration may occur. The fish BCF is reported as 130.

2-Butanone does not significantly sorb to soils and sediments and biodegradation and oxidation are the predominant fate processes. Reported half-lives indicate persistence does not occur. Bioaccumulation of 2-butanone is not expected to be significant. The fish BCF is reported as 0.33.

Volatilization, sorption to soils, bioaccumulation, and dechlorination are the major processes determining environmental fate and transport of PCBs. Environmental cycling of PCBs occurs through volatilization, air transport, fallout with dust and rain, and revolatilization. Volatilization from surface waters is considered to be significant; however, strong sorption to suspended sediments (especially clays or sediments with high organic matter) will reduce volatilization rates. Significant leaching from soils to ground water would not be likely under most conditions. Reductive dechlorination of the higher chlorinated congeners can occur in aquatic sediments. The dechlorinated products are generally less toxic and are subject to aerobic biodegradation.

Five areas of potential concern have been identified at the Ormet Corporation facility based on plant history and soil, seep water, ground-water, sediment, surface-water, and air sampling data. These areas are designated as: (1) former disposal ponds area; (2) CMSD; (3) former potliner storage area; (4) CRDA; and (5) the recreation fill area. The eastern portion of the facility, in which the potential source areas are located, is not readily accessed from the active production area and plant parking lots. With the exception of maintenance personnel, plant employee access to the eastern portion of the facility is limited to company picnics at the recreational area.

Available records indicate that the five former disposal ponds (1, 2, 3, 4, and 5) received, at various times from 1958 to 1981, sludges from the former air emissions wet scrubbing system (in Ponds 1 through 4) and tailings from the cryolite-recovery plant (in Pond 5). In general, constituent concentrations in waste-sludge reported in samples from Pond 5 were higher than those reported in the other samples from Ponds 1 through 4.

Currently, there is some vegetative covering on the surfaces of the five disposal ponds. The potential exists for direct contact with the surficial waste material/soil matrix in these disposal areas. Releases from the ponds are possible as a result of precipitation infiltration, precipitation runoff (overland), and air emissions of particulates (fugitive dust). Ponds 1 through 4 have more vegetation and more surface crusting than Pond 5; therefore, Ponds 1 through 4 have a lower potential for fugitive dust generation than Pond 5.

The former spent potliner storage area has some vegetative ground cover, similar to the former disposal ponds. Infiltration of precipitation through soils in this area is considered to be a much more significant source of ground-water alterations in the alluvial aquifer than other areas at the site.

The CMSD received assorted waste construction materials and other miscellaneous plant debris for approximately 13 years (from 1966 to mid-1979). The CMSD is located in the southeastern corner of the site, adjacent to Pond 5. The CMSD is covered with indigenous vegetation (e.g., grass and shrubs), limiting the potential for direct contact. The vegetation also restricts releases of particulates to the air (fugitive dust) or water (erosion).

The occurrence of five seeps which emanate from the southwest base of the CMSD are believed to be the result of precipitation infiltration through the relatively permeable materials disposed of in the dump. The precipitation likely percolates downward through the CMSD materials until reaching the underlying native soil, which is a low-permeability silt and clay formation. The seep water is then diverted laterally to the discharge points. Once discharged from the CMSD, the seep water follows the natural topography and flows overland a short distance to the Ormet National Pollutant Discharge

Elimination System (NPDES) Outfall 004 backwater area. Waters from the NPDES Outfall 004 discharge to the Ohio River.

The CRDA is located in the southwest portion of the site near the Ohio River. This is an area where stormwater runoff (in the past) deposited carbonaceous material from the anode crushing mill. The CRDA is covered with trees and thick undergrowth. Thus, the potential for direct contact with materials in this area is low. The potential for fugitive dust emissions from the CRDA is considered low due to the presence of dense vegetation on and around this area. Surface runoff from the CRDA follows the natural topography and enters the Outfall 004 backwater area.

The plant recreation fill Area is located in the northeast portion of the site adjacent to the Ormet baseball field. A relatively small amount of rubble was deposited on the face of a slope leading down to the baseball field. Two seeps which discharge from the base of this slope appear to be the result of precipitation, infiltration, and percolation through the northeast corner of Pond 5. The seep water drains east along the north edge of the baseball field for several hundred feet, then enters a small backwater area of the Ohio River.

The plume of affected ground water has been well defined (via the monitoring-well network) and is confined well within the Ormet property boundaries. The current ground-water pumping regime at the facility contains the affected ground water on-site.

Fugitive dust is a potential release mechanism from the former disposal ponds and the former spent potliner storage area. Monitoring of respirable dust (particulates) was conducted at four locations on site for a 10-month period. Depending on the wind velocity and duration and particle

size, off-site migration of fugitive dust is possible. The monitoring data and a computer model were used to calculate dust concentrations on-site and off-site.

Data from surface water and sediments collected in the 004 backwater area and locations adjacent to the site indicate above background levels of PAHs, various metals, cyanide, and PCBs, particularly in the 004 backwater area sediments. This suggests that stormwater runoff and/or seep discharge have acted as constituent-release mechanisms to the 004 backwater area.

7.1.3 Risk Assessment

A baseline risk assessment ("BRA") was conducted by Donohue & Associates (1992) on behalf of USEPA for the Ormet Site. The purpose of the BRA was to evaluate the potential adverse environmental and public health effects under current and hypothetical scenarios resulting from actual or potential releases of hazardous substances under the no-action remedial alternative. The results of the BRA indicate that exposure to constituents from the Ormet Site pose no risk of practical significance to current populations under current exposure scenarios. The results of the BRA are discussed in detail in two reports entitled "Baseline Risk Assessment, Human Health Evaluation, Ormet Corporation, Hannibal, Ohio", and, "Baseline Risk Assessment, Environmental Evaluation, Ormet Corporation, Hannibal, Ohio". These reports are provided as Appendix R to this report. A summary of the estimated cancer risks for current exposure scenarios is included in Table 98.

Based upon the BRA Report, a current population under a hypothetical scenario and a hypothetical future population under a hypothetical scenario could be exposed to carcinogenic

constituents of potential concern through several pathways. These hypothetical future scenarios are as follows:

- A future Ormet worker might be exposed to both Pond 5 emissions and the contaminated groundwater (in a no-pumping scenario).

- Future residents would be reasonably expected to be exposed via all quantified pathways.

The following tables summarize the estimated risks for lifetime exposure to carcinogenic constituents evaluated at the Ormet Site.

SUMMARY OF ESTIMATED EXCESS CANCER RISKS
CURRENT EXPOSURE SCENARIOS

Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Cancer Risk
Current Worker	Recreational Area	Pond 5 Particulates	Inhalation	9E-08
Current Resident, Adult	Proctor, WVA Ohio River	Pond 5 Particulates Fish	Inhalation Ingestion	4E-07 1E-01
Current Hypothetical Trespasser	Ohio River	Surface Water Surface Water Sediments Sediments	Ingestion Dermal Ingestion Dermal	2E-08 8E-10 3E-07 4E-06
Current Hypothetical Trespasser	004 Backwater	Surface Water Surface Water Sediments Sediments	Ingestion Dermal Ingestion Dermal	7E-08 1E-09 2E-05 2E-04

ESTIMATED CUMULATIVE EXCESS CANCER RISKS
HYPOTHETICAL FUTURE SCENARIOS

Exposed Population (Exposure Point)	Soil[a]	Air[b]	Ground-Water[c]	River[d]	004 Back-Water[d]	Sub-Total[e]	Fish[f] Ingestion	Total[g]
Future Maintenance Worker	—[h]	9E-08	5E-04	—	—	5E-04	—	5E-04
Future Plant Worker	—	—	1E-03	—	—	1E-03	—	1E-03
Future Resident (Downwind Pond 5)	—	7E-06	2E-03	8E-06	3E-04	2E-03	1E-01	1E-01
Future Resident (Pond 5)	3E-04	—	2E-03	8E-06	3E-04	3E-03	1E-01	1E-01
Future Resident (Ponds 1-4)	1E-03	—	2E-03	8E-06	3E-04	3E-03	1E-01	1E-01
Future Resident (Potliner)	7E-03	—	2E-03	8E-06	3E-04	9E-03	1E-01	1E-01
Exposed Population (Exposure Point)	Soil[a]	Air[b]	Ground-Water[c]	River[d]	004 Back-Water[d]	Sub-Total[e]	Fish[f] Ingestion	Total[g]
Future Resident (Carbon Runoff)	1E-03	—	2E-03	8E-06	3E-04	3E-03	1E-01	1E-01
Future Resident (Construction Material Scrap Dump)	5E-03	—	2E-03	8E-06	3E-04	7E-03	1E-01	1E-01

(a) Includes ingestion and dermal exposures. Values from Table 5-3 of the BRA Report included in Appendix R.
(b) From Table 5-1 of the BRA report included in Appendix R. Value for current worker assumed to equal value for future maintenance worker.
(c) From Table 5-2 of the BRA report included in Appendix R.
(d) From 5-2 of the BRA report included in Appendix R. Includes both ingestion of and dermal contact with surface water and sediments. Fish ingestion scenario not included here.
(e) Exclusive of fish ingestion scenario.
(f) From Table 5-5 of the BRA report included in Appendix R.
(g) Total is the sum of the subtotal column and the fish ingestion risk estimate.
(h) "—" indicates pathway not quantified.

These values are presented such that total estimated risk exclusive of the fish ingestion pathway is also included. It is recognized that the addition of all future residential scenarios results in a carcinogenic risk summation that is likely to be greater than the reasonable maximum (as defined as the 95th percentile of distribution). It is unlikely that any hypothetical future resident would consistently face a reasonable maximum exposure from every pathway quantified in the BRA.

The potential for non-carcinogenic effects is evaluated by summing hazard quotients (HQs) (i.e., the ratios of chemical-specific intakes over a specific time period to the chemical-specific reference dose (mg/kg - day) derived for a similar exposure period). Since some individuals are exposed by more than one pathway, hazard index values are summed for each pathway that may contribute to the exposure of an individual in a given population. If the total hazard index is equal to or less than 1 (1E+00), it is believed that non-carcinogenic health effects will not occur.

The following tables summarize the estimated risks for lifetime exposure to non-carcinogenic constituents evaluated at the Ormet Site.

SUMMARY OF ESTIMATED NONCARCINOGENIC RISKS
CURRENT EXPOSURE SCENARIOS

Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Hazard Index
Current Worker	Recreational Area	Pond 5 Particulates	Inhalation	6E-03
Current Resident, Adult	Proctor, WVA	Pond 5 Particulates	Inhalation	1E-01
	Ohio River	Fish	Ingestion	1E-01
Current Resident, Child (subchronic)	Proctor, WVA	Pond 5 Particulates	Inhalation	1E-02
	Ohio River	Fish	Ingestion	1E-01
Current Hypothetical Trespasser	Ohio River	Surface Water	Ingestion	2E-03
		Surface Water	Dermal	5E-07
		Sediments	Ingestion	4E-04
		Sediments	Dermal	6E-04
Current Hypothetical Trespasser	Backwater Area (004)	Surface Water	Ingestion	2E-03
		Surface Water	Dermal	3E-07
		Sediments	Ingestion	3E-04
		Sediments	Dermal	6E-05

SUMMARY OF ESTIMATED NONCARCINOGENIC RISKS -
HYPOTHETICAL FUTURE SCENARIOS[a]

Exposed Population	Exposure Point	Exposure Medium	Exposure Route	Hazard Index
Future Plant Worker, No-Pumping Scenario	CAC Drinking Water Well	Groundwater	Ingestion	3E+01
Future Maintenance Worker, No-Pumping Scenario	CAC Drinking Water Well	Groundwater	Ingestion	2E+01
Future Resident, Adult	Pond 5 - Downwind	Pond 5 Particulates	Inhalation	4E-01
Future Resident, Child	Pond 5 - Downwind	Pond 5 Particulates	Inhalation	3E-01
Future Resident, Adult	Future Drinking Water Well	Groundwater	Ingestion	1E+02
	Ohio River	Surface Water	Ingestion	1E-03
	Ohio River	Surface Water	Dermal	2E-07
	Ohio River	Sediments	Ingestion	3E-04
	Ohio River	Sediments	Dermal	3E-05
	Ohio River	Fish	Ingestion	1E-01
	004 Backwater	Surface Water	Ingestion	1E-03
	004 Backwater	Surface Water	Dermal	1E-07
	004 Backwater	Sediments	Ingestion	2E-04
	004 Backwater	Sediments	Dermal	3E-05
Future Resident, Child	Future Drinking Water Well	Groundwater	Ingestion	6E+02
	Ohio River	Surface Water	Ingestion	6E-03
	Ohio River	Surface Water	Dermal	2E-07
	Ohio River	Sediments	Ingestion	1E-03
	Ohio River	Sediments	Dermal	6E-05
	Ohio River	Fish	Ingestion	1E-01
	004 Backwater	Surface Water	Ingestion	7E-03
	004 Backwater	Surface Water	Dermal	1E-07
	004 Backwater	Sediments	Ingestion	8E-04
	004 Backwater	Sediments	Dermal	9E-05

(a) Future residential soil pathway scenarios summarized in Table 5-7 of BRA report included in Appendix R.

SUMMARY OF ESTIMATED NONCARCINOGENIC RISK - HYPOTHETICAL FUTURE RESIDENTIAL SOIL PATHWAYS

Exposure Point	Exposure Route	Hazard Index [a]	
		Resident Adult	Resident Child
Pond 5	Ingestion	2E-01	1E+00
	Dermal	5E-05	2E-04
	Total:	2E-01	1E+00
Ponds 1-4	Ingestion	4E-01	3E-00
	Dermal	4E-04	3E-03
	Total:	4E-01	3E+00
Potliner	Ingestion	1E-01	8E-01
	Dermal	5E-04	2E-03
	Total:	1E-01	8E-01
CRDA	Ingestion	5E-01	3E+00
	Dermal	9E-05	5E-04
	Total:	5E-01	3E+00
CMSD	Ingestion	2E-01	1E+00
	Dermal	3E-03	3E-02
	Total:	2E-01	1E+00

(a) For the adult this is a chronic hazard index; for the child the hazard index is subchronic.

As shown in the preceding tables, no hazard indices calculated for assumed current exposure scenarios exceeded 1E+00. Some hazard indices may exceed 1E+00 for assumed hypothetical future scenarios.

7.2   Conclusions

7.2.1 Data Limitations and Recommendations for Future Work

This section discusses the data available to characterize soil, water, and air conditions at the Ormet site, and supplemental data that would be useful to support current interpretations. To simplify review, each of the potential source areas and other media investigated at the Ormet site are discussed separately in terms of the types and amount of data presently available, and what types of additional data, if any, may be warranted. The areas and media considered in this section include the following:

- Former Disposal Ponds,

- Former Spent Potliner Storage Area,

- Carbon Runoff and Deposition Area,

- Former Construction Material Scrap Dump,

- Plant Recreation-Area Fill,

- Ground Water,

- Surface Water

- Sediments

- Air

- CAC Ranney Well

7.2.1.1   Former Disposal Ponds

The present data available to characterize the chemical makeup of solids in the former disposal ponds are substantial, and include analyses for CLP inorganics, CLP organics (less pesticides and 2, 3, 7, 8 dioxin), and other non-CLP parameters (e.g., fluoride, cyanide amenable to chlorination, sulfate, and chloride) on 47 pond solids samples from specified intervals throughout the vertical depth of the pond solids. No additional pond-solids analyses are needed to define current conditions.

The depth and approximate volume of materials in the ponds has been adequately approximated by soundings performed at specified points on the pond surfaces.

Ground-water quality associated with the former disposal ponds (particularly Pond 5) has been characterized by analyses for CLP inorganics, CLP organics and other non-CLP parameters on samples from wells hydraulically downgradient from the pond (i.e., MW-14, MW-17, MW-33S&D, MW-34 S&D, MW-39S&D, and MW-42S&D). These data indicate that current pond-related effects on water quality are much less significant than water-quality impacts related to the former spent potliner storage area.

7.2.1.2   Former Spent Potliner Storage Area

The present data available to characterize the chemical makeup of soil beneath the former spent potliner storage area include Phase I analyses for primary indicator parameters (pH, total cyanide, fluoride, and sodium, as well as calcium, and ammonia) on 132 samples from specified vertical intervals at 24 boring locations. Phase II analyses were performed on an additional 20 samples

from 4 selected locations, and included CLP inorganics and CLP organics (less pesticides and 2, 3, 7, 8 dioxin). The present data base is considered adequate to characterize soil conditions within the former spent potliner storage area.

Ground-water quality associated with the former spent potliner storage area is well documented by data obtained during the RI. These include analyses for CLP inorganics, CLP organics, and numerous other non-CLP parameters (e.g., pH, fluoride, cyanide amenable to chlorination, TOC, silica, TDS, and others).

7.2.1.3   Carbon Runoff and Deposition Area

During the Phase I RI, the chemical make up of the carbon deposits within the carbon runoff and deposition area were characterized by analyses for CLP inorganics, CLP organics (less pesticides, PCBs, and 2, 3, 7, 8 dioxin) and non-CLP parameters on 7 carbon samples and 7 samples of natural clay from beneath the carbon deposits. In addition, a sample of the carbon material was collected by the USEPA Environmental Response Team during the site ecological survey and analyzed for pesticides, PCBs, and 2, 3, 7, 8 dioxin. The thickness and approximate volume of the carbon deposits have been determined by push-tube samples or hand-dug pits to the base of the carbon. Overall, the data available for the carbon runoff and deposition area are considered adequate for the RI interpretations.

7.2.1.4   Former Construction Material Scrap Dump

The contents of the former construction material scrap dump have been characterized by discussions with plant personnel, and by visual inspections along exposed faces and in backhoe-excavated pits. A total of 5 samples of soils from the pits have also been analyzed for CLP inorganics, CLP organics, and other non-CLP parameters. Also, a sample of oil/water from Test Pit #2 was analyzed for PCBs by Method 8270. The current data are considered adequate to characterize the contents of the former construction material scrap dump.

The quality of seeps associated with the former construction material scrap dump (seeps #2, 3, 5, and 6) has been determined by analyses for CLP inorganics, CLP organics and other non-CLP parameters on samples from two of the seeps during Phase I and samples from all four of the seeps during Phase II. These data are considered adequate to support RI interpretations regarding seep quality.

7.2.1.5   Plant Recreation-Area Fill

Data from soil borings drilled during the Phase I RI indicate that the rubble along the face of the slope leading down to the ballfield areas is confined to the slope and does not represent an extensive disposal area. Borehole samples were visually inspected and logged, and no further characterization of this area is needed to support RI interpretation.

Seeps identified in the ballfield area (seeps #1 and #4) were sampled and analyzed for CLP inorganics, CLP organics, and other non-CLP parameters. During Phase I, Seep #1 was analyzed

(Seep #4 was not flowing) and during Phase II both of the seeps were sampled and analyzed. These data are considered adequate to characterize seep quality and to support RI interpretations.

7.2.1.6   Ground Water

Ground-water quality and flow conditions at the Ormet site have been well defined by water-level and water-quality monitoring performed during and prior to the RI. During the Phase I RI ground-water samples were analyzed for CLP-inorganics, CLP organics, and numerous other non-CLP parameters. During Phase II, analyses for selected parameters (e.g., pH, iron, sodium, fluoride and cyanide) were performed on additional samples from 13 of the wells and two field duplicates, along with low part-per-trillion analyses for PAHs on a total of 9 samples (six samples and three field duplicates).

7.2.1.7   Surface Water

Surface-water quality within the backwater area and the Ohio River has been characterized by analyses for CLP inorganics, CLP organics and other non-CLP parameters. The Phase II RI work included analyses of a sample from the backwater area, and a total of five samples and sample duplicates from the Ohio River. These data are considered adequate to characterize surface water quality conditions.

7.2.1.8   Sediments

Sediment quality within the backwater area and in the Ohio River adjacent to the Ormet site has been characterized by analyses for CLP inorganics, CLP organics, and other non-CLP parameters. Phase I work included collection and analysis of a sample from the backwater area and six samples or sample duplicates form the Ohio River sediments. Phase II work included the analyses of an additional sample from the backwater area and 13 additional samples or sample duplicates from the Ohio River sediments. The existing sediment quality data are considered adequate for the purposes of RI interpretations.

7.2.1.9   Air

Data regarding air-transported respirable particulates were obtained by a 10-month long monitoring program that included use of high-volume air samplers at locations determined to be downwind of the former disposal ponds and the former spent potliner storage area. These data are considered adequate to support interpretations regarding air transport of respirable particulates.

7.2.1.10   CAC Ranney Well

Two sample sets of ground water from the CAC Ranney well were collected and analyzed for CLP inorganics, CLP organics, and other non-CLP parameters, as well as drinking water parameters. These data, along with documented flow conditions at the Ormet site, indicate that the CAC Ranney well is not being impacted by water quality conditions beneath the Ormet site. No additional data from the CAC Ranney well are needed to support RI interpretations.

GERAGHTY & MILLER, INC.

7.2.2 Recommended Remedial Action Objectives

Remedial action objectives have been developed for each of the environmental media at the Ormet site that have been affected by hazardous substances, pollutants or constituents, and that pose unacceptable risks to public health, welfare or the environment. The remedial action objectives are derived from the NCP and based upon exposure pathways identified for the site. It should be noted that certain findings and conclusions of the baseline risk assessment are currently being re-evaluated. Therefore, the remedial objectives established for the site may require revision to reflect the final baseline risk assessment. The following remedial action objectives for the Ormet site are presented in Table 106 and summarized in the following paragraphs:

7.2.2.1   Human Health Objectives

The remedial objective for carcinogens will be to reduce the cumulative cancer risk under the future residential exposure scenario to 10^{-4} to 10^{-6} for ingestion, inhalation, and direct contact exposure pathways, with a 10^{-6} point of departure for total exposure from all pathways present at the Ormet site, as stated in the Baseline Risk Assessment. The remedial objectives for non-carcinogens will be to reduce the cumulative health hazard index to less than 1.0 under the future residential exposure scenario for total exposure from all pathways at the Ormet site, as stated in the Baseline Risk Assessment.

GERAGHTY & MILLER, INC.

7.2.2.2   Environmental Protection Objectives

For soils, sediments, ground water, and surface water, the recommended environmental protection objectives are to remediate to conditions that do not result in adverse effects (i.e., toxicity or bioaccumulation potential) in exposed organisms and to prevent degradation of the overall environmental quality. The remedial action objectives for air will be to prevent deposition of airborne contaminants that adversely effect exposed organisms and to prevent degradation of overall environmental quality.